SILICON CHIP

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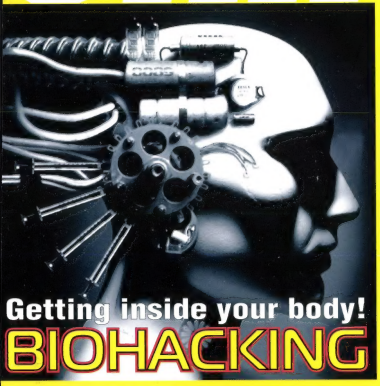

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✓Current
✓Resistance

We review:

Incredible Nikon Coolpix P900 ULTRA HIGH POWER ZOOM

83x Zoom (24 – 2000mm), WiFi, VR, AF, GPS...

Jaycar Electronics
Better, More Technical

KIT OF THE MONTH

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SILICON CHIP NOV/DEC '12 KC-5513

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$55

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FOR BOATS SILICON CHIP SEP/OCT '10 KC-5498

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- PCB: 104 x 78mm

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FOR MOTOR BIKES SILICON CHIP MAY '08 KC-5466

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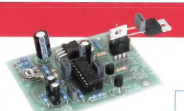
ELECTRONICS AUSTRALA MAY '87 KA-1683

This simple electronic voltmeter with 10 LED indicators lets you monitor the condition of your car's battery.

- PCB: 62 x 39mm

Kit supplied with PCB and all components.



$27.95

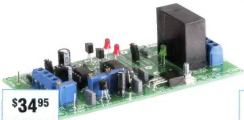
10A 12VDC Motor Speed Controller

SILICON CHIP JUN '97 KC-5225

Ideal for controlling 12VDC motors in cars such as fuel injection pumps, water/air intercoolers and water injection systems. The circuit incorporates a soft start feature to reduce inrush currents.

- PCB: 69 x 51mm

Kit includes PCB and all electronic components.



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SILICON CHIP JUL '14 KC-5528

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SILICON CHIP AUG '01 KC-5317

Silicon Chip Magazine August '01

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$16.95

Clifford The Cricket Kit

SILICON CHIP DEC '94 KC-5178

Clifford hides in the dark and chirps until a light is turned on – just like a real cricket. Clifford's LED eyes flash when he sings.

- PCB: 40 x 35mm

Kit supplied with PCB, piezo buzzer, LDR plus all electronic components.

$17.95

Contents

SILICON CHIP

Vol.28, No.8; August 2015 www.siliconchip.com.au

Features

16 A Look At Biohacking
Biohacking is a relatively new phenomenon and ranges from the simple and familiar to the bizarre. Here's a quick rundown – by Dr David Maddison

26 Nikon's Incredible P900 Camera
It's got an 83x optical zoom lens and gives impressive results – by Kevin Poulter

45 DMM Calibration
Do you trust your multimeter? Now you can use our Voltage/Resistance/Current Reference to check and calibrate it – by Nicholas Vinen

48 Battery Fighters Won't Leave You Stranded
Don't let a flat battery leave you stuck out the back of Woop Woop – Ross Tester

50 Review: Keysight 34470A 7.5-Digit Multimeter
It boasts high measurement precision, a 4.3-inch LCD, standard USB and Ethernet ports, high-speed data logging modes and more – by Nicholas Vinen

62 Electronex: The Electronics Design & Assembly Expo
Electronex returns to Melbourne from 9-10th September

96 Here is Me – And Here is Mini-Me!
Fancy a 3D version of your mini-self? In paper, plastic or resin? Mini-Me 3D scanning and printing is being introduced at Officeworks – by Kevin Poulter

Projects To Build

32 Ultra-LD Mk.4 200W RMS Power Amplifier, Pt.1
Our new Ultra-LD Mk.4 has even lower distortion than the Mk.3 version, is more compact and now includes a LED clipping indicator – by Nicholas Vinen

40 Accurate Voltage/Current/Resistance Reference
This low-cost, accurate voltage, current and resistance reference is just the shot for checking and calibrating multimeters – by Nicholas Vinen

66 Build A Driveway Monitor, Pt.2
Part 2 this month has the full construction and installation details. You can build it to operate just the way you want – by John Clarke

84 LED Party Strobe Mk2
It's based on a standard 230VAC 30W LED floodlight which can be purchased quite cheaply. You just build a small PCB module to control it – by Ross Tester

Special Columns

76 Circuit Notebook
(1) PICAXE-Based Mains Timer; (2) Simple Solar Charge Regulator For Campers; (3) Simple Switchmode LED Flasher

89 Serviceman's Log
My love/hate relationship with cars – by Dave Thompson

98 Vintage Radio
The 1955 Fleetwood 4-Valve 1003 – by Associate Professor Graham Parslow

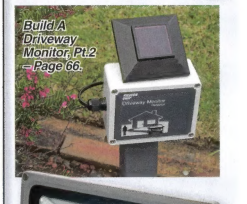
Departments

2 Publisher's Letter
4 Mailbag
61 Product Showcase
104 SC Online Shop
106 Ask Silicon Chip
111 Market Centre
112 Advertising Index
112 Notes & Errata

Nikon's Incredible P900 Camera With 83x Zoom Lens – Page 26.

Ultra-LD Mk.4 200W RMS Power Amplifier, Pt.1 – Page 32.

Accurate Voltage/ Current/ Resistance Reference – Page 40.



Build A Driveway Monitor, Pt.2 – Page 66.

Build A LED Party Strobe – Page 84.

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Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc. (Hons.)

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Ross Tester
Jim Rowe, B.A., B.Sc
Nicholas Vinen

Photography
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Brendan Akhurst
David Maddison B.App.Sc. (Hons 1), PhD, Grad.Dip.Entr.Innov.
Kevin Poulter
Dave Thompson

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Editorial office:
Unit 1, 234 Harbord Rd,
Brookvale, NSW 2100.

Postal address: PO Box 139,
Collaroy Beach, NSW 2097.

Phone (02) 9939 3295.
E-mail: silicon@siliconchip.com.au

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Publisher's Letter

Electrical safety standards are not being observed

Recently, I installed a number of mains-powered LED floodlights on the outside walls of my home. They were purchased from an Australian supplier but are clearly manufactured somewhere in Asia. Since they were so cheap and much cheaper if purchased in quantities of two, three or more, I purchased more than I needed for the immediate installation. In fact, one of them is featured in the Party Strobe article in this issue. I should also say that the cost of the electrician's time in having cables run in the cavity brick walls of my home far outweighed the purchase cost of the floodlights. Nevertheless, I was generally happy with the installation. However . . .

On receiving the floodlights I immediately used a multimeter to checked that the green/yellow lead in the power cable was, in fact, connected to the metalwork. I then used our Appliance Insulation Tester from the April 2015 issue to check that aspect as well. Each one passed. I then disassembled each floodlight, in order to check the state of the internal wiring. Generally, it was OK. The very short mains lead was double-sheathed, used the correct wire colours and was securely anchored with a plated metal cable gland. However, termination of the Earth lead to the metal case was definitely below standard as it was crudely soldered to the securing nut of the cable gland and then had a dollop of silicone sealant over it. If it is to meet Australian Wiring Standards (AS:NZS 60065:2012), the Earth lead should be terminated to the metalwork with a crimped eyelet connector, screw, nut and lock-washer.

On the other hand, the switchmode LED current driver appeared to be safely secured on a bed of silicone sealant, effectively isolating the metal case of the driver from the metal housing of the floodlight. Also, depending on the internal construction of the LED driver, the whole thing could possibly have passed the tests for a double-insulated appliance, making the earthing of the case unnecessary. But while these floodlights have CE stickers on the outside, we doubt whether they have been subjected to any standards testing, in any country.

As well, these units give the impression that they have been thrown together in a great hurry. For example, the reflectors on a couple of them had been damaged by carelessly-wielded power screwdrivers and the mounting brackets were too wide for the floodlight housings and would not allow them to be mounted squarely to the wall. The assembly workers are probably being paid an absolute pittance – which is why these units are so cheap. To solve the problem of the wonky mounting brackets I cut a section from each one of them, much to the chagrin of the electrician doing the installation. His comment about these lamps was "These are rubbish!" I had to agree with him.

I should mention that these lights do produce a fair amount of electromagnetic interference and would probably wipe out AM radio reception in weak signal areas. Finally, after a month or two, all the plated screws are rusting because I live close to the beach. I will need to replace them with stainless steel screws.

This episode points to the fact that we are now importing vast quantities of cheap manufactured goods, some of which does not meet Australian standards or EEC standards, for that matter. Nor is this comment confined to electrical standards – it is across the board. This represents a safety risk to the vast majority of the population, most of whom have no technical knowledge at all. Is there any obvious solution to this dilemma? Not really. We enjoy these cheap goods from all over the world and the downside is that some of this stuff simply does not meet the relevant standards.

If you have technical knowledge you can take steps to check goods before you use them and/or you can also purchase from an Australian supplier, in which case our consumer laws do apply. Apart from that, it's a case of "let the buyer beware".

Leo Simpson

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Grid-tied inverter anti-islanding is not bullet-proof

Your Publisher's Letter in the July 2015 edition implied that the anti-islanding feature of PV inverters was fairly bullet-proof. In the real world, this is unlikely to be the case. Should an accident bring down a power line in the middle of a sunny day, the break will not be clean and there could be a large number of inverters from different manufacturers on the non-grid side of the break. There is a good chance that the right combination of different anti-islanding techniques and complex loads will keep this segment alive.

The only solutions to this that I know of are a grid-fed tone or crowbar to earth relays on each segment. Either solution would require a very expensive retrofit of the network.

With grid power becoming more expensive and less reliable and PV systems becoming cheaper, and with most people not being able to understand why they can't have power when the grid is down and the sun is shining, I am sure that this will create a black market in inverter mods and switchboard rewiring that will likely electrocute people and burn down houses.

This problem will only disappear when the large price difference between grid and off-grid or hybrid kit is reduced. The Tesla PowerWall battery solution can only work in this environment if there is strong government intervention to reduce the cost disparities. Short of the Greens winning the election, I do not see this happening.

Mark Baker,
South Perth, WA.

Grid-tied Inverters & anti-islanding

The subject of your Publisher's Letter in the June 2015 issue has also occupied my mind on the odd occasion and in the end I have determined that performing the necessary modifications to an existing grid-tied inverter system would be too difficult and too expensive to be worth the trouble.

This is my thinking on the matter. Grid-tied inverters will not start unless they detect mains supply at correct voltage and frequency and there is also sufficient DC voltage being generated by the PV panels. At the output of the inverter there is a mains sensing circuit which ensures that grid voltage and frequency are present and correct and within normal range. Only when verified and sufficient output from the PV panels is detected will the inverter go through a start-up procedure. When the inverter output is synchronised with the grid supply the output of the inverter is connected to the grid.

Probably the easiest way to bypass the anti-islanding situation during a grid outage, assuming the grid is isolated automatically by a contactor, is to add a battery-powered alternative source of 240VAC at 50Hz sinewave in order to fool the inverter into executing a normal start-up procedure. Since the alternative source would simply be taking the place of the normal grid supply it follows that it would be connected to the household load at the time of the outage.

This means it must be capable of supplying the load presented to it without the reference voltage or frequency being affected, otherwise the inverter will be unable to properly synchronise and connect to the load.

This implies that the alternative source which is used to fool the GT inverter into performing start-up would need to be of reasonably high power output in order to handle any likely load at the time of the outage without its own output characteristics being affected. If it were possible for the mains sensing circuitry to be made accessible via a connection point which is not directly connected to the household load then it should be possible to work around the anti-islanding function.

Solution for headphone listening with hearing aids

I refer to the letter requesting a headphone amplifier for the hearing-impaired by T. S., of Tauranga, NZ, in both the May & June 2015 issues and Bob Denton's letter in the Mailbag pages of the July 2015 issue.

I too have hearing aids in both ears and have had trouble in privately listening to TV. I tried a personal hearing loop but found the frequency roll off at the higher frequencies unacceptable when listening to speech and music. I then tried a stereo headphone amplifier, with over-the-ear headphones, without the hearing aids and found that I was unable to compensate when using the TV balance and tone controls.

Using my hearing aids with the over-the-ear headphones resulted in too much feedback, even with the volume controls of the hearing aids turned to their lowest setting. I went to the local hardware store and purchased a metre of about 12mm diameter round foam plastic filler. I cut two pieces to length and fitted them inside of the ear pads of the headphones to space the speakers further from the hearing aids and this works very well. I have to turn the hearing aid volume down one click for the left ear and two clicks for the right.

So I do not require the stereo headphone amplifier and the sound is as good as it is in the real world. One pair of headphones had to have the ear pads glued in place as, with the foam spacers inserted, the tension was too great for the pads to remain attached to the body.

I hope this idea helps some more of us hearing-impaired of the world.

Lee Bourgeois,
Mittagong, NSW.

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Mailbag: continued

Tricking a grid-tied inverter may still be possible

After reading the Publisher's Letter in the July 2015 issue, it was obvious that tricking a grid-tied inverter was not an easy proposition. However, I refuse to accept that it cannot be done. I think the glitch protection of the Pawsey supercomputers (described in the same issue) using a large flywheel and motor suggests a method.

No grid-tied inverter will easily change the frequency of a motor with a large flywheel which further suggests a diesel-powered alternator. But having said that, if inverters would not operate with small generators, at what size would they start to operate? Should small towns with diesel power forget about installing solar panels etc?

The Pawsey Supercomputing article was most interesting, particularly since I wasn't aware of it. Last year, I visited the Supercomputing Organisation website but I cannot remember any mention of the Pawsey computers. I do remember that almost all of the world's top supercomputers were very large arrays like Magnus and they were based either on Intel devices or Nvidia devices. In any case, they are effectively toys for the elite paid for by us and not accessible by us.

However, both the Intel and the Nvidia devices are commonly available devices and a little while ago I watched a program or read an article in which Nvidia's Tegra 4 processor was used to process video in real time. It was being used to recognise people, street signs, cars etc in an experimental driverless car.

The Tegra consists of four ARM Cortex-A15 CPUs, a battery saver Cortex A15 core and a 72-core Nvidia GPU. What's more, it is available in development PCBs, the Jetson TK1 and the Jetson TK1 Pro. I think the Jetson TK1 was priced at $192 USD – see www.nvidia.com/jetson-tk1

In the Mailbag pages of the same issue, Ned Stojadinovic joked about no solar power at night. My brother-in-law visited his homeland in eastern Europe a little while ago where he was told about "solar" power being generated at night. The government was paying very generously for solar power and one or more enterprising people took advantage of the offer.

Government officials wondered why solar power was being generated at night and found that some people had diesel generators feeding into the grid. Obviously, there was a profit to be made. It is just another case of a bad policy producing unwanted results.

George Ramsay,
Holland Park, Qld.

tion using a cheaper low-powered 240VAC/50Hz device.

However, I suspect that such a modification to a GT inverter would be beyond the average person and even experienced technical persons might find it too difficult. But there is more . . .

Having solved the start-up situation so that we can avail ourselves of power supplied free from the Sun during a grid outage we may now discover that the installed system is not large enough to cater for the usual household load. Most existing systems installed are only capable of providing approximately 50-60% of the average power requirement, with the rest being supplied by the grid.

On cloudy overcast days, 100% of the loading might be supplied from the grid. In order to adequately provide for a fairly normal household load while disconnected from the grid, the size of existing systems would need to be increased by as much as 50% or more. This might present a problem for larger houses having a high daily power usage because the maximum size of domestic systems is limited to 10kW.

While the current cost of PV panels and a larger capacity inverter might not be considered an undue burden they would still amount to a considerable outlay – and the existing inverter is probably of no further use. Then there is the question of having sufficient roof area for the additional panels and a larger mounting space for the new inverter. Add to this the installation costs.

It is also required to inform the power provider of any changes to the system and this might mean a reduction to any rebate being received for power exported to the grid – especially where a 10-year rebate contract is in place.

Nevertheless, if it is thought that it is viable to go even further and become fully independent of the grid during outages, a back-up battery is mandatory. Retrofitting existing systems would require a charge control regulator to be added as well as battery isolation logic and switching to prevent the battery being discharged at night or on cloudy days while still connected to the grid.

In summary, to achieve grid-free mains power supply during outages it is necessary to overcome the start-up voltage and frequency requirements which are normally supplied by the grid. Even without going to the expense of a back-up battery it would be necessary to increase the size of the system to make up for the power normally provided by the grid, especially on cloudy days.

Assuming that battery back-up is adopted, then charge control and battery isolation logic and switching would have to be incorporated, otherwise the householder could find that when he needs to operate from the battery it is found to be discharged due to having sent power out to the grid during the night.

I hope this is food for thought to those who think that it should be easy to overcome the anti-islanding function of grid-tied inverters so that power can still be provided from their PV system on sunny days. It is a rather complex set of problems which need to be overcome and it is my opinion that rather than going to the trouble of converting an existing system it would be cheaper to invest in a new battery backed GT inverter such as manufactured by Shneider Electric (formerly Xantrex) – www.homepower.com/available-battery-based-grid-tied-inverters

The problems to be overcome are even greater for households which have a 3-phase connection, where the load is distributed over the three phases – as in my case.

Ross Herbert,
Carine, WA.

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Mailbag: continued

Anti-islanding may pose a safety issue

Leo Simpson's Publisher's Letter in the June 2015 issue made for interesting reading and I agree that the latest battery technology should be employed to allow users of solar power to have power during a blackout. However, I believe Leo has overlooked a significant emerging danger.

It is stated that the anti-islanding feature is there for the safety of linesmen. This is all very well until you imagine a situation where several houses, most with solar feeds to the grid, are suddenly isolated from the grid by the lines being disconnected due to an accident.

One presumes that the anti-islanding feature works by detecting the sudden increase in load caused by the many homes and businesses which do not have solar power. In the situation I have described, there would be no such increase in load, since the power lines have been physically disconnected from the grid.

If the anti-islanding feature is disabled by such a situation, the inverters could continue to feed power back into the lines, perhaps supplying several non-solar homes in the same isolated section. Thus the lines would remain "live" even though disconnected from the grid.

The possibility of this occurring is less if the anti-islanding feature also looks for a sudden decrease in load but it is still a possibility and a frightening one. It only needs to occur once for an unwary electricity linesman to be killed.

Even if fatal contact with the live lines is avoided, upon reconnection to the grid, the phase of the "island" of power would be well out of sync with the grid which would introduce dangerous complications upon reconnection.

Jonathan Waller,
via email.

Solar power and the triple bottom line

With the utmost respect, I do not believe the article in the May 2015 issue by Dr Alan Wilson, entitled "Home Solar Panel Electricity: Is It Worth It?", has really answered the question. He has produced some very useful data but most of us could have worked out for ourselves that if we put in a big enough system, together with a large enough high-technology solar hot water system and a separate gas home heating system, then we could get to the position that our net consumption from the grid could reach zero (exports = imports). We just have to be willing to spend a big enough heap of money up front.

In my view, to answer the question we must consider the triple bottom-line – what are the economic, environmental and societal implications? To answer the economic question, surely it is important to consider the time-value of money and economic life considerations? In other words, we must consider inflation, interest rates, escalation and depreciation effects, by means of a Discounted Cash Flow calculation – Nett Present Worth ($1 today is worth a whole lot less than it was 20 years ago – and this might be the panel lifetime?).

We really can't say our electricity bill is zero to prove the "green" benefits, if we have spent excessive capital up front. We would also need to include the ongoing costs of maintenance, eg, the replacement of inverters.

I have heard that the MTBF (mean time between failures) of cheaper imports is not that great. Plus, the panels will require eventual replacement when their output falls excessively.

Another factor I suspect is not being considered (but I've found it difficult to obtain solid data, so stand to be corrected) is that of contribution to the infrastructure costs of generators, transmission towers, meters, power poles, wires etc. As the electricity retailer is able to offer off-peak power at nearly half the cost of peak power I would presume without making a huge loss, it would seem reasonable that the peak surcharge is being recovered to deal with the maintenance, replacement and expansion of the grid infrastructure. The daily "Supply Charge" just

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Mailbag: continued

Solar power calculations are not future-proof

I agree that prospective buyers of solar power must carefully do their sums. I did the calculations in mid-2012 when the day (peak) rate was 23.2c/kWh, the night rate (off peak) was 12.14c/kWh and the solar rebate was 28.83c/kWh. At that time, there was no supply charge which today is $1.45 per day and for a typical 90-day account is $130.50.

I calculated that I would be in credit for summer and would have almost nothing to pay through winter. How was I to know what lay in wait? Today the day rate is 36.12c/kW, the night rate is 17.16c/kW and the solar rebate is 6.2c/kWh. My latest bill up to 20 April 2015 is $563.08 and with a solar rebate of $77.61, the total amount due is $485.47.

With solar power I am now saving 86 cents day. The system cost about $6500 after the government rebate and with a saving of 86c/day I estimate that I will be ahead in 20.7 years, assuming that there are no further price rises and reductions in solar rebates. By then I will be 96 years of age and probably in care if I am alive!

My system has 20 panels rated at 240W each. On a clear sunny day, I should generate 4.8kW peak. It never happened. From 1st January 2015 to 1st April 2015, I generated 1280kWh or 14.2kWh per day. If you're considering solar power, then I suggest you forget it. It's easier to turn off unwanted lights and heaters etc.

David Voight, VK3FDV,
Kirwans Bridge, Vic.

doesn't seem large enough to cover it and it may simply be for the retail costs such connecting, billing, and managing customer accounts.

The societal impact is that those without panels would be heavily subsidising those who still want access to the grid at their convenience but are not willing to contribute to that infrastructure cost. Is this true? We do note that energy costs appear to be "going through the roof".

If so, I feel this cost should really be included within the analysis. If the "green" response is that the answer is simple – we should all have PV installed – then my question is "who then pays for the infrastructure costs?" To my mind, if those with PV cannot go "off-grid" economically, then the whole argument is a "crock". Perhaps the new Tesla PowerWall (featured in the June 2015 issue) will be the answer.

Ian Thompson,
Duncraig, WA.

Hot water temperature is a health issue

In the Mailbag pages of the June 2015 issue of SILICON CHIP, your correspondent Ross Herbert describes his solar panel installation augmented by a solar hot-water system. He also describes an electric booster circuit which keeps the water "moderately hot for showering" and suggesting that it is at a temperature which would not need any cold water added.

According to the Water and Sewerage Act of 2001, water heaters are required to be kept at a minimum of 60°C in order to prevent the growth of legionella bacteria. Operating a water heater at a lower temperature than this could be a health hazard in terms of the aforesaid bacteria, not to mention being against the law.

Furthermore, the temperature has to be reduced to no more than 50°C when it arrives at the sanitary fitting (shower etc). This results in standard water systems having their thermostats set at no lower than 60°C and the outlet being fed into a mixing valve to reduce the temperature arriving at the fixture to be no more than 50°C for residential buildings.

Brian Day,
Mt Hunter, NSW.

Restored vintage radios may still not perform well

I refer to the panel on page 87 in Vintage Radio for July 2015 entitled "How Far Do You Go With Restoration?" Many old radios, especially those with vacuum tubes, even if they have been restored to exactly the same performance as when they came out of the shop, can be still pretty hard to live with. Lack of automatic gain control (AGC) results in blasts of sound as the set is tuned from station to station. The elementary audio system is highly distorted and bearable only if lots of treble cut is applied, not to mention the rattles from the speaker.

I believe that a general article on making old radios liveable by updating the circuitry and at the same time leaving the general external appearance original would be of interest to many readers.

One item that fails on many early sets is the speaker transformer. It is usually not possible to buy a direct replacement. Some investigation I have done suggests that 240VAC filament transformers can be used and these can provide better results than the original.

Maurice Findlay,
Badgerys Creek, NSW.

Switchmode power supplies & radio interference

I noticed the linear voltage regulator supply article in the May 2015 issue. It should be benign as far as radio interference is concerned. By contrast, most switchmode (buck) supplies cause FM-band interference and this can be problem with dashcams and GPS units. Have you performed any spectra analyses on switchmode units? Currently, the UBEC model aeroplane switchmode power supply has the lowest interference we have been able to source.

We have a solar array on a terracotta-tiled roof to heat the salt-water pool. A by-product of it leaking has been rusted guttering and downpipes. This is the same maintenance problem as mentioned the Publisher's Letter on solar panel installations in the May 2015 issue. No tiles were wind or bird-damaged though.

Alan Greaves,
St Clair, NSW.

Comment: we would expect that most switchmode supplies would cause interference to AM radios in areas with weak signals. However, we would not expect much interference at all in the FM band.

It would be easy enough to do spectrum analyses of typical switchmode supplies but whether there would be

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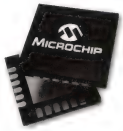

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Mailbag: continued

Headphone amplifier for hearing-impaired (1)

I have read that you are considering the presentation of a small stereo amplifier/equaliser for use with headphones for private watching of television. I would like to give my support for this idea.

There are numerous devices available for the hearing-impaired. Almost all are miniaturised, mainly for cosmetic reasons and all are very expensive. In a busy home with background noise of the family chatting away, the one respite is a pair of good-quality headphones with large ear-muffs to block out external noise.

However, for the hearing-impaired, the lack of an equaliser network with headphones results in poor intelligibility. This is an excellent suggestion and I heartily support it.

Prof. B. Foss Leach CNZM (Retired),
Dr Janet M. Davidson ONZM, FRSNZ (Retired),
Martinborough, NZ.

much interference to FM radio in a particular case would depend on whether the tuner had a poor capture ratio and you were in a weak signal area where the tuner was not providing full quieting (ie, ~50dB signal-to-noise ratio or better).

Headphone amplifier for hearing-impaired (2)

In the Ask Silicon Chip pages of the June 2015 issue, you were asking for readers to declare interest in a proposed amplifier/equaliser for the hearing-impaired.

I would be interested in such a project although I am not sure if it is possible to incorporate circuitry to reduce the volume of loud effects or background noise/music that is present in many TV or film soundtracks. Some years ago, one of your correspondents described rewiring stereo headphones to reverse the phase of the audio in one earpiece that was supposed to alleviate the problem but I have had no success with this.

Maybe if the effects is mono and the dialogue is stereo there might be some magic you can work. I have tried using a 5.1 home-theatre amplifier to attempt to find a channel with clear dialogue but no success; they all have audio graffiti. Another suggestion is to power the device from a USB or HDMI port on a TV so that batteries and power switching is not required.

I have had some correspondence with the ABC on the issue of TV dialogue being obscured by other added sounds and the detrimental effect that it has on the millions of citizens who have hearing difficulties. I haven't had a helpful response; they seem to be more interested in allowing the program producer to exercise his creative whims rather than having program dialogue clearly understood.

The ABC also make it impossible to have correspondence with anybody in real authority; maybe the person responding to email queries is a junior staffer that has a repertoire of pre-prepared responses to almost every query. I even asked the ABC to consider broadcasting one channel (maybe the centre front) with clear dialogue but no joy from them.

Bob Hambling,
Cornubia, Qld.

Comment: we discussed this topic quite a few years ago. A partial solution is to set your TV's sound into mono mode, if that is possible. This can also help when watching sports broadcasts as it cuts down audience noise.

More on adjusting mechanical vibrators

I'd like to reply to Ross Stell's comments on adjusting mechanical vibrators, on page 12 of the July 2015 issue. I'd like to thank Ross for taking the time to correct a number of mistakes I made in my description of the AWA Radiola 523-M vibrator radio as described in the May 2015 issue of Silicon Chip, as well as providing additional information on vibrators. I encourage anyone who didn't read Ross's letter to do so.

In my statement about the various frequencies of vibration of vibrators I should have been more careful with the wording. What I wrote gave the impression that the frequency of vibration could be varied in individual vibrators, when what really I meant was that different vibrators were designed to run at different frequencies. For example, the large Van Ruyten vibrators used to convert DC to 230V 50Hz square-wave AC vibrate at 50Hz and as Ross says, the MSP/Oak vibrators operate at 110Hz.

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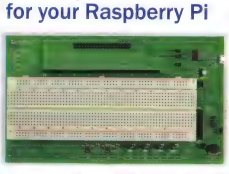

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Hum in audio systems

Hum in audio systems can be due to many different causes. One of the most common is ground loops but hum can also be due to a broken earth connection. Recently, I set up an tuner/CD/mixer/amplifier and found a low-level but annoying hum. The lead from the mixer to the amplifier consisted of two RCA plugs at one end and a tip-ring-sleeve mini-jack at the amplifier end. Replacing the lead fixed the problem but I wanted to know what was wrong with it.

To my great surprise, I found that the earth braids were connected to the tip of the jack and the two audio signals were to the ring and the sleeve. No wonder the system gave trouble! A brief Google search suggested that there is no standard for tip-ring-sleeve plugs but I can't believe this is true. Surely the standard is that the sleeve is earth (since sockets are typically mounted on a metal chassis) and the audio signals go to the tip and ring.

A likely clue to the problem is that one RCA plug was white and the other yellow. Perhaps the lead was from a camera or other non-audio device. I wonder if anyone else has encountered this problem?

James Goding,
Princes Hill, Vic.

Comment: your understanding of the standard for ring/tip/sleeve wiring is correct. It is evident that some products simply are not subject to quality control testing before they are packed and despatched.

My statement that "it's either a double-pole or 4-pole switch . . ." is a case of me using the wrong terminology and I should have written it like Ross has.

I was interested to read about the adjustment of the vibrator points and only someone with considerably more experience with vibrators than I have would know how this should be done. In my servicing days, we would just replace the vibrator or do work on them much as I described.

Rodney Champness,
Mooroopna, Vic.

Query on Nixie clock circuit operation

I'd like to ask a question in regards to the Retro Nixie Clock PSU published in the February & March 2015 issues of Silicon Chip. On your circuit diagram on page 28 of the February issue, there is nothing connected to the pin 2 (SE) of REG1, essentially leaving the internal transistor's emitter floating. Can you please clarify how and why it works then?

Dmitry Pakhomenko,
Wentworthville, NSW.

Comment: on the face of it, this circuit works in spite of an obvious lack of connection to the emitter at pin 2 of REG1. In fact, this portion of the circuit is exactly the same as featured in the original Nixie clock present in the July & August 2007 issues.

Many hundreds of these clocks have been built without a power supply fault being evident; so it works in spite

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Mailbag: continued

Life of $LiFePo_4$ batteries

Following the article on $LiFePo_4$ batteries by Stan Swan in the June 2013 issue of SILICON CHIP I decided to give them a try. I purchased a quantity of AA Litelong brand cells, some dummies and a suitable Soshine charger from the supplier referenced in the article.

Other than some variations in capacity these cells have performed exactly as the author stated and are now installed in multiple devices around my home and workshop. I now have a couple of dozen of these and recharging is a simple matter of putting them in the charger and ensuring it is switched to the right battery type.

I decided to apply the same approach to a quantity of equipment which uses AAA cells. I purchased eight cells from the same supplier, along with dummies. Two were DOA and would not take a charge and four have failed after one use. All the AAA cells were Coolook brand.

Trying to understand what was happening, I came across the following statements in an eBay listing from an Australian supplier of the same Soshine charger as I am using: "when charging protected batteries, always re-insert or pull back the batteries several seconds after charging commences. This breaking of connection/interruption of the charging cycle will help ensure the over discharge protection mode of the battery is properly released and help prevent overloading the charger. This step is especially important when the batteries are in protection mode or are fully drained".

Although I am not familiar with the protection mode referred to, I tried this approach and after several insertions and removals in the charger, two of the previously dead cells are now taking a charge. The other two have not responded.

I also read a comment on another site that the physical size of an AAA cell is too small to allow $LiFePo_4$ chemistry to function properly but I have been unable to verify this.

Can you shed any light on the behaviour of these AAA cells, the concept of protection mode and whether $LiFePo_4$ AAA cells can be expected to be as reliable as their bigger brother AA cells?

Barrie Davis,
Hope Valley, SA.

Comment: we are not aware of this behaviour of AAA cells. Perhaps other readers can comment.

of the error. Strictly speaking though, pin 2 of REG1 should be connected to 0V. However, most constructors will probably prefer to leave things as they are and not disturb a working clock.

Elaborate measures to avoid blackouts are not justified

I was one of those with a wonderful shiny panel installation and no power for six days, and who considered the alternatives available. Although the idea of redirecting the output of a grid-tied inverter to power the house is appealing, it is unlikely to work in practice. Grid-tied inverters are designed to take a varying power source and transfer all of it to a low resistance sink. Inverters designed to supply domestic and industrial power are designed to transfer power on demand from a low resistance source to a varying sink.

It may be possible to design an inverter to take the output of panels directly to supply a varying load but it is unlikely to be practical. Consider if the refrigerator decides to switch on as a cloud passes overhead. The panels may or may not be able to supply the start-up current, with unpredictable results. This is clearly unsatisfactory and the practical solution is to have some battery storage capable of supplying peak power demands, regardless of the instantaneous input from the panels.

The introduction of batteries makes things complicated. How and when will they be charged? How is the switch from panel power to battery power achieved? These questions have been considered by many people and solutions are out there.

For instance, the Tesla PowerWall is not just a battery; it incorporates smarts to regulate battery charging and discharging so the PowerWall can mimic solar panels when panel output is inadequate. But it does not address the grid connect versus house power problem. It seems there is no universal answer; each situation has its own solution.

A truly uninterruptible supply can be achieved by running the whole house from an inverter supplied by batteries. The batteries can be charged from the grid, from solar panels, or when necessary from a generator. And the option exists to run a grid-tied inverter from the batteries when desired. I worked where this was partially implemented on a grand scale.

The building was supplied by a 2MW inverter drawing power from a bank of batteries. The batteries were normally continually charged from the grid but were able to supply enough power to keep the inverter running for several minutes if the grid failed. Within a minute, a back-up generator started automatically and ran until grid power was restored. The system worked faultlessly and provided power that was not affected by external variations such as spikes, brown-outs or interruptions.

But is this level of sophistication needed in a domestic situation? During the power outage our entertainment was a transistor radio running off four D cells from a couple of torches. Lighting was provided by a 12V trouble lamp running off a spare car battery. These both lasted the distance.

Our landline has one standard telephone, which continued to work. We cooked on gas and were able to shower and charge mobile phones elsewhere.

After a couple of days it was necessary to throw away the fridge contents. Inconvenient, yes. But these are all first-world problems. And this was the first time in 40 years we had an outage long enough to require the fridge to be emptied. From an economic point of view, there is little point in spending more than a few dollars to prepare for a similar outage that may not occur in our lifetime.

I believe there is no merit in trying to adapt the existing configurations to provide back-up power when the grid fails. At the very least, some form of battery storage is mandatory and it introduces a whole lot of new questions.

If there is a need for supply security, the system should be designed from scratch. Such a system is more likely to look like a RAPS (remote area power supply) system with grid connect capability. Then a move to go off-grid would be possible if desired.

However, there are good arguments for not going off-grid. First off, there is redundancy. Our solar system was completely destroyed by a lightning strike – all panels and the inverter. Apart from the insurance excess, this was of no consequence to us, even though it took four months to replace. Imagine the problems if we were off-grid.

Additionally, the ability to charge batteries from off peak-power means the amount of battery storage and number of panels is significantly reduced with minimal cost for the grid power. A RAPS system is designed for worst-case situations and will spend a lot of time with fully-charged batteries and panels in sunlight but no demand. Also, an intelligent grid can draw on customer batteries at times of peak demand, reducing the need for large power stations and lowering transmission costs by drawing current from batteries located near the consumers.

If the power companies pay an appropriate price for the exported power, rather than the few cents they give today, there is a net return that will offset the cost of being grid-tied to some extent. Conversely, if there is a substantial movement to go off-grid where a grid exists, it will create chaos. The cost of the grid has to be funded by consumers and a diminishing consumer base will end up with rising connection costs. This will accelerate the move to off-grid systems resulting in a vicious cycle with unknown consequences.

My conclusion is that being frustrated by the way grid-tied inverters work is fruitless. If there is a real need for a back-up system, go buy an MPPT charger, some batteries and a sine-wave inverter sized for the necessities. When the power fails, redirect the solar panels to the charger and run extension leads to where they are needed. My solution was to buy another set of D cells and recharge the car battery.

Alan Cashin,
Islington, NSW. SC

Pawsey Supercomputer seems unduly hungry

With respect to the Pawsey Supercomputer article in the July 2015 issue of SILICON CHIP, its power consumption of 900MW is a lot of power; equivalent to a large coal-fired power station. Does this supercomputer at the Pawsey centre really use that much power? I doubt it.

Peter Henderson,
Cessnock, NSW.

Geoff Graham comments: it should have been 900kW. And that article was checked by the engineers at the Supercomputing Centre!

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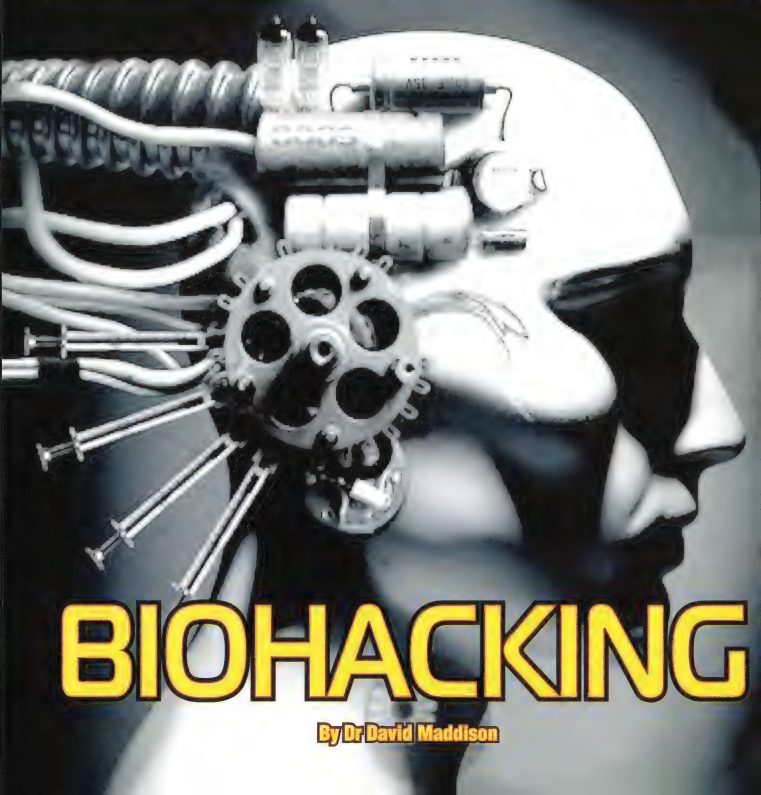


BIOHACKING

By Dr David Maddison

Biohacking is a relatively new phenomenon, of amateurs applying the "hacker" philosophy to the human body or other biological processes. Biohackers seek to improve either the physical or the biological function of their own bodies or of other organisms or, potentially, invent whole new organisms. A wide range of practices and ideological approaches apply to biohacking.

It is important to note that biohackers are (with some notable exceptions) primarily of an amateur, do-it-yourself background. Institutional involvement is not generally sought nor considered desirable but the boundaries of biohacking are not strictly defined. And there are areas of overlap both with the individuals and the devices involved.

Take for example, an RFID chip – it is a "mainstream" device. However, when it is encapsulated in a biocompatible coating and then implanted into a human by someone who is not a surgeon, it enters the territory of the biohacker.

There are two main types of biohackers.

One type are the "grinders" who primarily develop or use either non-invasive hardware attachments for the human body (eg, electrodes to enable biofeedback) or actual hardware implants.

Implants are known generally as "wetware" within the grinder community – although this highlights some definitional issues within the biohacker community, Wikipedia defines wetware as "elements equivalent to hardware and software found in a person, namely the central nervous system (CNS) and the human mind".

The second type of biohackers are the amateur biologists who develop chemical and biological enhancements for the human body or stand-alone projects involving genetic modification of organisms. A simple example of a biological biohacking project is to implement a certain dietary regimen to enhance vision (which we will discuss later).

Another very basic biohack, familiar to everyone, is a morning coffee to enhance performance – although most would not consciously do that as a biohack.

Work on advanced synthetic biology which may even involve genetic sequencing or genetic modification which is done in so-called "biofoundries" is also possible.

The scope of biohacking ranges from the simple and familiar to the extreme and bizarre.

Editor's note: readers may be familiar with other common forms of bio-hacking, some of which have been practiced for more than a century. This includes bodybuilding (whether natural, using over-the-counter supplements or anabolic steroids), performance enhancement for athletes (including breathing restriction/altitude training, blood transfusions and various drugs including EPO). Other performance-enhancing drug use includes healthy males taking Viagra and military personnel, long distance drivers etc taking amphetamines to improve alertness.

Blame the 'net!

Biohacking is mainly possible because the Internet allows information sharing on a massive scale and the development of communities with similar interests. It also allows scientific research and technology development outside the traditional institutions and the purchase of material from all over the world at very low cost.

Biohackers are generally connected with the ideologies of transhumanism and the biopunk movement, although no such ideological commitment is necessary. In this article we will focus on the technology, not the philosophies of the movement.

WARNING!

Many of the activities described here could be hazardous and even life-threatening. Silicon Chip specifically warns you not to attempt any DIY medical procedures (including biohacks and implants) on yourself or anyone else.

The scope of biohacking is significant and so to place things in some perspective we have attempted to categorise the different areas of practice. Note that there is no overall agreement on biohacker definitions so we have made our best attempt based on the information available.

The following main areas will be discussed:

Grinders – implanted devices; body enhancement through use of diet or pharmaceuticals

Non-invasive devices – for use by biohackers

Synthetic biologists – non-grinder biohackers

Organisations and communities – for biohackers

Note that space only allows discussion of some representative examples of biohacking, not all projects or organisations can be discussed.

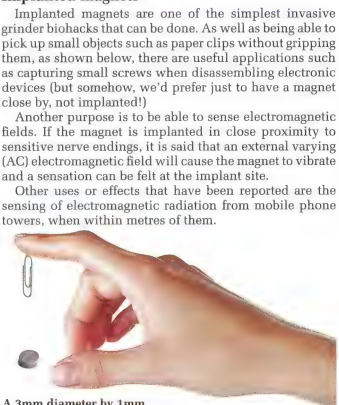
GRINDERS – Implanted devices

Implanted magnets

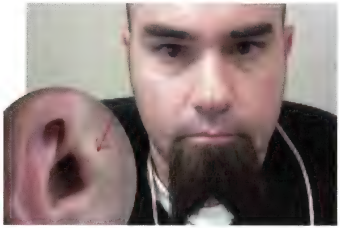
Implanted magnets are one of the simplest invasive grinder biohacks that can be done. As well as being able to pick up small objects such as paper clips without gripping them, as shown below, there are useful applications such as capturing small screws when disassembling electronic devices (but somehow, we'd prefer just to have a magnet close by, not implanted!)

Another purpose is to be able to sense electromagnetic fields. If the magnet is implanted in close proximity to sensitive nerve endings, it is said that an external varying (AC) electromagnetic field will cause the magnet to vibrate and a sensation can be felt at the implant site.

Other uses or effects that have been reported are the sensing of electromagnetic radiation from mobile phone towers, when within metres of them.



A 3mm diameter by 1mm thick titanium nitride-coated neodymium magnet as sold by a biohacking supplier (https://dangerous- things.com/) and a demonstration of a possible use.



Musician Rich Lee with inductive coil around his neck and inset showing where the magnet was implanted.

A technician reported being able to sense live wires or components which were to be avoided (***warning, do not rely on this method to keep you safe!***), feeling vibrations from an operating microwave oven nearby, sensing the power setting of an electric stove heating element and sensing of electrical on-off events inside machinery.

Yet another use is to be able to distinguish between ferrous and non-ferrous materials that may be painted or, one imagines, being able to detect filler in the panels of a used car one might be interested in buying!

For a video of someone using an implanted magnet see "*My Magnetic Implant*" https://youtu.be/kznWw1EcHXs

RFID and NFC

RFIDs (or Radio Frequency IDentification devices) will be familiar to many SILICON CHIP readers.

A typical RFID device (as implanted in a pet) compared to a grain of rice.

Usually unpowered, when probed with an appropriate radio signal, they return information stored on them.

They are designed to act as a unique identifier for the object, animal or human they are attached to or implanted in. These devices, now used by biohackers, are commonly implanted in pets and livestock for identification and are found in key fobs to open doors. They offer one-way communication only.

A similar, related, device also used by biohackers is the NFC, or Near Field Communication device, a more advanced device than an RFID as they have more memory and can engage in two-way communications.

These are increasingly found on smartphones and are intended to allow two devices to communicate when touched together or at least bought into close proximity. They can both send and receive data or act in a peer-to-peer mode and be paired to a variety of devices. They can also be used for contactless payment systems.

Eyeborg

Last month, in Part 2 of the The Bionic Eye series, the work of biohacker Neil Harbisson was mentioned. He considers himself the world's first "cyborg" and has a "stalk" called the Eyeborg attached to his skull that enables him to translate colours into sounds in order to allow him to interpret colours.

The sounds are transmitted through the bones of his skull to his ears and this enables him to hear a wider range of sounds than if he listened to them in the normal way.

He suffers from having monochromatic vision and this is the only way he can interpret colour. The device is sensitive into both the UV and infrared parts of the spectrum, detecting colours beyond what the human eye is sensitive to.

The device has some other functions as well, as explained last month.

An Australian biohacker

Australia has its own biohackers. Melbourne man Alex Smith is one example. He has several implants done either by himself or by body modification artists.

One device is an implanted magnet in a finger of his left hand (as shown overleaf). Alex says that it is able to sense electromagnetic fields.

For example, Alex can detect mains-voltage electrical cables which are live, although only when they are drawing a high current such as when connected to a heater, not a low current as when connected to a phone charger.

He can also feel a sensation when on a tram as it is accelerating and it is drawing a high current; he also feels a sensation when walking past high-powered electrical transformers and operating microwave ovens.

In addition to the magnet, he has two RFID devices and one NFC device, all of which are located in his left hand.

One RFID device is rewriteable and is used for opening electronically operated doors that are compatible with the device and have the appropriate access code. It also contains medical information.

The other RFID device he has implanted is read-only and has a temperature sensor, which can sense the temperature of his body at the location in which it is implanted and can wirelessly transmit the data to an external device.

He is presently working on an Arduino-based device equipped with a Bluetooth transmitter to receive the temperature data and then transmit it to a phone or other device to be logged.

Finally, Alex has a Near Field Communication (NFC) device implanted which enables him to access his password-protected phone without having to type in or swipe a password.

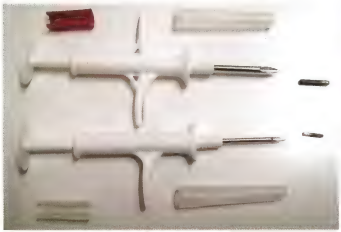
One RFID device has a few tens of bytes of programmable memory and the NFC device has just under a kilobyte of programmable memory.

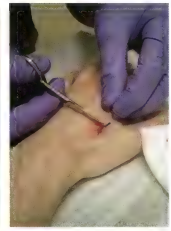
For Alex's next project he would like to install a multi-electrode array interfaced to his nervous system, probably to the medial nerve in his forearm.

What happens when new improved RFID devices are released and adopted by the biohacker community?

Alex says that he will remove the existing devices (or have them removed) and have them replaced with upgraded devices. It is not feasible to simply retain the obsolete devices as there is insufficient room in the hand to do so.

Alex has a website at https://cyberise.me/index.php





(Left): Examples of RFID and NFC injecting devices with chips to the right of the needles. (Middle): Alex having one of his implants injected and (Right): sewing up after the procedure. This is normally done without anaesthetic.

You can hear Alex in an interview on ABC-RN on the Bodysphere program at www.abc.net.au/radionational/programs/bodysphere/wonders2c-freaks-26-bio-hackers/6269536. His comments begin at the 20 min 18 sec mark at http://mpegmedia.abc.net.au/rn/podcast/2015/03/bse_20150308.mp3.

Grindhouse Wetware

Grindhouse Wetware (www.grindhousewetware.com/) is a group of six biohacking enthusiasts (three women, three men) based near Pittsburgh, USA whose premises are the basement of a house.

They have developed several devices as follows:

BottleNose: The BottleNose is an external device designed to interact with an implanted neodynium magnet.

It is an ultrasonic rangefinder device that drives a coil, which makes the implanted magnet vibrate (so called "haptic" feedback) thus enabling a blindfolded person to sense distance information.

A *very* early prototype version of the BottleNose built into a glove.

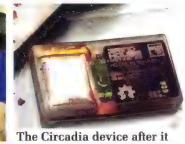
An early prototype (v0.1) of the device can be seen in the video *"BottleNose"* at https://youtu.be/usfxAJKB7gA.

NorthStar: The NorthStar is an implantable device under development which will detect hand gestures and also be able to detect magnetic north and subdermal LEDs will glow more strongly the closer the device is pointed to magnetic north.

The Circadia device before implantation (in the plastic bag) with its interface unit (black).

Circadia: The Circadia was an implantable computer that was connected to the world via Bluetooth, could be charged inductively through the skin, had LEDs and would also measure body temperature at the implant location.

Circadia device after implantation. Note the thickness of the device and the blue computer screen, showing data being transmitted from the device. LEDs on the unit can also be activated; when done so they can be seen glowing beneath the skin (see video).



The Circadia device after it was removed. Those familiar with lithium polymer batteries will immediately recognise the reason for the device failure – a "puffed" battery. Devices made by mainstream manufacturers are subject to many years of testing and animal trials before such devices are implanted.

The device was about the size of a credit card but was about 10mm thick. It was implanted in the forearm of Grindhouse co-founder Tim Cannon but had to be removed some time later as there were battery problems.

For a video on the implant and use of the Circadia see *"Experimenting with Biochip Implants"* https://youtu.be/clIiP1H3Opw

Professor Kevin Warwick: Apart from Neil Harbisson (mentioned above), there is a competing contender to the title of the world's first cyborg in Professor Kevin Warwick, professor of Cybernetics at Reading University in the UK. In 1998 he had an RFID chip implanted in his arm.

Professor Warwick is an example of a biohacker working within a mainstream institution. His RFID device was implanted by a professional medical doctor and it enabled a computer to track his movements as he walked around the university corridors. He could also remotely operate doors, lights and other devices.

In 2002 he had another device, a 100-electrode array, implanted in the median nerve of the left arm. In this device a 25-channel neural signal amplifier amplifies and

filters the signals which are then digitised and scanned for neural events. Only 25 of the 100 electrodes could be monitored at one time.

He could use this device to control an electric wheel chair and also a robotic hand. A similar device was implanted in his wife and they were able to communicate electronically via the neural interface, in the sense that if she moved her hand the electrical signal from her nerves was transmitted to him and he received a corresponding electrical stimulus but did not move his hand. The device was removed after 96 days, apparently because the leads started to deteriorate.

For more details see **www.ingenia.org.uk/ingenia/issues/issue16/warwick.pdf**. A video of the implant procedure and its subsequent operation can be seen at "*Kevin Warwick's BrainGate Implant*" **https://youtu.be/LW6tcuBJ6-w**. BrainGate is now owned by Blackrock Microsystems. Also see "*Kevin Warwick, Human Cyborg*" **https://youtu.be/Fhu0VBCAW6k**

This electrode array from Blackrock Microsystems is similar to the one that Kevin Warwick had implanted. It is 4mm x 4mm with elecrodes 1.5mm long, and has a variety of lead and connector options. See **www.blackrockmicro.com/index.aspx**

Professor Steve Mann

Professor Steve Mann is another example of an institution-based biohacker. He is notable for his projects in wearable computing and in particular his EyeTap, which pre-dates Google's Glass by a significant margin.

His device, permanently attached to his skull, is like a heads-up display for the eye and records and adds enhancement information to what the wearing is seeing; for example, geographical data or statistics at a sports game or information about a building or restaurant.

For a video of the device see "*Steve Mann explains the EyeTap*" **https://youtu.be/DiFtmrpuwNY**. His blog is at **http://eyetap.blogspot.com.au/**

Steve Mann's EyeTap device which is attached to his skull.

Memory Devices

It would be great to have an implanted memory device that would act as your personal USB drive; one that is always with you and that you never lose. This seems not to be practical at the moment, although no doubt it will come.

It is certainly feasible to get a large amount of memory into a very small space (for example, as in the microSD card format) but the problem is how to get the data in and out. Having wires, cables or tubes come through the skin is difficult enough for professional biomedical engineers to do, let alone anyone else.

The process of establishing conduits through the skin is not reliable in the long term and is subject to infection and rejection. The only practical way way to interface an implanted memory device is through wireless radio or optical protocols. The problem with those techniques is that, even though they work, the rate of data transfer is too slow to be practical for most applications involving access to many gigabytes of data.

To give an example of the sort of data rate that might be achievable through the skin (transdermally) with a radio frequency inductive link, consider that a commercial device, the Medtronic CareLink programmer for cardiac pacemakers, operates at 120Kb/s. At this speed, it would take nearly 30 hours to read the content of a typical 16GB memory card!

Using an infrared optical data link through the skin at an interface speed of around 1Mb/s has been demonstrated by researchers at Johns Hopkins Applied Physics Laboratory but even at this speed, it would take an unacceptably long time to read or write large amounts of data to the memory chip.

Researchers at Korea University in Seoul have demonstrated data transmission rates of 10Mb/s from one area of skin to another but it is not clear if this technology could be utilised for transdermal data transmission. Even if it could, the data rate would still be very slow for memory access.

It is clear then that getting large amounts of data into and out of the body at a high speed remains a challenge. Unfortunately, the dream of an implanted memory chip with high speed access to masses of data does not appear to be feasible at the moment. There is, of course, no problem if low speed data access is acceptable, as it would be for some applications.

For the future – the exocortex

An exocortex is a theoretical device that is interfaced to the brain and would augment the biological brain with such things as extra processing power, extra memory, access to the Internet via thought alone and various sensory and input and output devices such as wireless communications.

While such hardware devices do not exist now the mere possibility to quickly and simply access the Internet anywhere we go gives a sense of what it might be like to use such a hardware device.

We could discover almost any fact instantly and many people wouldn't even bother to learn or remember things because they would know that the answer is instantly available to them (not that not learning or remembering in the traditional sense is a good thing).

Biohackers might be able to make rudimentary exocortex devices via the use of EEG headsets as described below to control appropriate computer hardware.

Oh the pain, the pain . . .

As biohacking is in the realm of amateurs, albeit, highly informed ones, the vast majority of biohack implants are done without anaesthetic, as it would not be ethical for medical doctors to participate in this do-it-yourself surgery – especially with devices that have not been through the normal testing protocols.

There are of course medical "professionals", particularly in third-world countries who could be persuaded to do certain procedures for an appropriate fee. Such possibilities are often discussed in biohacker forums.

Video

For a video on some aspects of the grinder stream of biohacking you might like to watch "*Biohackers: A journey into cyborg America*" https://youtu.be/K0WIgU7LRcI Warning – there are images of medical procedures done by non-surgical personnel and there is some bad language.

GRINDERS – Chemical Enhancement/Diet

A few examples are as follows:

Human NIR vision project

Some people have attempted to hack their visual system to extend the wavelengths to which the human eye is sensitive (usually around 390nm to 700nm wavelength, corresponding to 430 to 790THz).

A group of four biohackers, Peyton Rowlands, Jeffrey A Tibbetts, Gabriel Licina and Ian Galvin established a crowdfunding project to see if they could use dietary means to extend their vision into the near-infrared. They are from the biohacking collective, *Science for the Masses*, http://scienceforthemasses.org/ (see below for more information).

The idea behind this vision hack was to replace one of the photopigments in the eye with a different one that is sensitive further into the infrared.

The basis of the hack dates to 1939, when George Wald, the man who discovered the role of Vitamin A in vision, discovered a photopigment in freshwater fish that enabled them to see into the infrared (ie, wavelengths above ~700nm). The idea was to see if this fish photopigment could somehow be formed in the human eye.

The human eye naturally has the photopigments photopsin in the cone cells and rhodopsin in the rods. These are made of a protein complex, comprised of opsin and and retinal or vitamin A1. The purpose of these photopigments is to convert incoming light into signals that get sent to the optic nerve to be interpreted as vision by the brain.

The fish photopigment is called porphyropsin and is made of opsin and 3,4-dehydroretinol or vitamin A2 and it was expected to replace the natural photopsin and rhodopsin pigments. It was thought by the biohackers that humans could use vitamin A2 to make photopigments instead of vitamin A1 and the result would be the production of the fish photopigment instead of the human one.

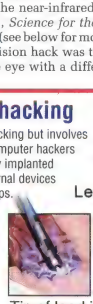
As the the body has a much greater affinity for A1 instead of A2 it was necessary to eliminate A1 from the diet. This was done by using a custom blend of Soylent which is a total food substitute (which did not have vitamin A of any kind) and then adding A2. Again, do not try this.

Malicious biohacking

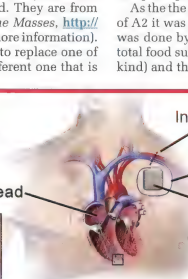
This is not strictly biohacking but involves conventional, malicious computer hackers gaining access to medically implanted biomedical devices or external devices such as drug infusion pumps.

Access can be gained over computer networks which connect to the device via wires or wirelessly or via Bluetooth or proprietary wireless protocols.

Drug infusion pumps can infuse various drugs such as morphine, chemotherapy agents and antibiotics.



Tip of lead in right ventricle of heart



The pumps are connected to patients via intravenous lines. Newer pumps may have web interfaces to enable their remote management by nursing staff and they also have built in safety features to ensure drugs are introduced within safe limits of dose over an appropriate time period.

Barcodes on intravenous drug packages enable the device to know what drug is being administered and the device looks up a library which is on the local network to ensure the drug has been set to an appropriate safe dose by nursing staff.

Various vulnerabilities have been found in some devices that might enable malicious hackers to alter the dose of drug being delivered. For more information see www.wired.com/2015/04/drug-pumps-security-flaw-lets-hackers-raise-dose-limits/

Insulin pumps are connected wirelessly to a controller so that patients or medical staff can adjust various parameters. In 2011 McAfee's Barnaby Jack demonstrated vulnerabilities of a commercial insulin pump and could take control of any device within 100 metres of him.

For more information see www.theregister.co.uk/2011/10/27/fatal_insulin_pump_attack/

Implanted cardiac defibrillators and pacemakers are further devices that might be vulnerable to malicious medical hackers.

In the case of the defibrillator, it was actually demonstrated by Barnaby Jack in 2012 that a laptop could be used to cause a defibrillator to either refrain from delivering a shock when necessary or to deliver one when not necessary, by using the wireless transmitter in a laptop from 10 to 15 metres away.

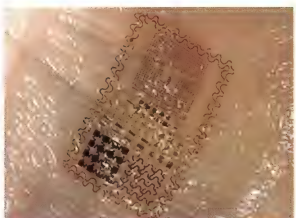
The concern was real enough that former US Vice President, Dick Cheney, when he got his defibrillator upgraded to a later model when he was in office in 2007, asked that its wireless functionality be permanently disabled to stop hackers remotely gaining control of the device and assassinating him, although Barnaby Jack had not yet demonstrated the possibility of doing this.

This scenario was also the subject of an episode of the Homeland TV series entitled Broken Heart (Season 2, Episode 10) in which a hacker gained control of the US Vice President's pacemaker and assassinated him.

There are many other medical devices that may be vulnerable to attack such as CT Scanners (they could be programmed to deliver an excessive dose of X-rays), lab analysis equipment (it could be made to give false results) and medical robots.

The consequences of a hacker gaining control of a surgery robot is too horrible to even contemplate.

Presumably, now that these vulnerabilities have been demonstrated, companies have taken appropriate action to improve the device's security.



(Above): an epidermal electronic device as it appears when adhered to the skin. (Right): physical layout of epidermal electronic device showing various components.

The project is now completed and a success was claimed with vision out to 950nm. But the project has also attracted criticism as to methodological soundness and neuroscientist Brian Jones says there is no way that photopigments can physically see light beyond 650nm.

This idea was also originally tried by the US Navy during WWII, in an effort to improve night vision and the results were apparently promising but then infrared vision systems were developed. Sailors were fed the livers of walleyed pikes as a source of vitamin A2.

Another type of visual enhancement is to be able to see into the ultraviolet spectrum. This has not been done by biohackers but is an incidental consequence of having the lens of the eye removed. The lens normally absorbs light in the UV spectrum but when it is removed, a condition known as aphakia occurs. Some people have been reported to be able to see UV light in the range of 300 to 400nm. (Wavelengths of light shorter than 300nm are blocked by the cornea.) Even when the lens is replaced with an artificial one, say to treat cataracts, there are reports of this ability.

This "hack" is somewhat reminiscent of the software hack to remove the infrared filter from a digital camera to make it sensitive in the infrared.

A retired US Air Force engineer, Alek Komarnitsky, had cataract surgery and his natural lenses were removed and replaced with artificial ones. He then discovered he could see into the UV spectrum and has a very interesting website discussing his enhanced vision. (www.komar.org/faq/colorado-cataract-surgery-crystalens/ultra-violet-color-glow/).

Artist Claude Monet had one lens removed when he was 82 due to cataracts and it is said that his paintings after that demonstrated his new ability to see into the UV spectrum.

Night enhancement eyedrops using Chlorin E6

Another project of Science for the Masses is night-vision enhancement using the natural photosensitising chemical and anti-cancer agent Chlorin E6. This chemical is relatively easy to extract from many green plants. Just because it is "natural" does not mean it is safe to use and you should not try this.

Preliminary results of this work, although not reported in peer-reviewed scientific literature, have the instigators of the study claiming some success in enhancing of night vision in healthy volunteers.

Caloric restriction

Caloric restriction is a dietary biohack with claimed efficacy for lifetime extension in some non-human organisms in which it has been tried. There are many people who are subjecting themselves to a dietary regimen with limited food intake in the belief that they will live longer, healthier lives. This is not yet proven to work in humans and there could be serious side effects to one's health, not the least of which is permanent tiredness. There are ongoing academic studies in this area.

Non-invasive devices

Two examples are as follows:

Epidermal electronics

While not strictly a biohack as it has a mainstream institution behind its development (although, as we have said, the boundaries of this technology are not strictly defined), the new area of epidermal electronics would appear to have potential uses for biohackers as it involves non-invasive devices that are applied to the skin and can be used to monitor various physiological parameters.

Researchers headed by Professor Nanshu Lu at the Cockrell School of Engineering at the University of Texas have developed "electronic tattoos" that can be adhered to the skin and have been demonstrated to be able to monitor EEG (brain), ECG (heart) and EMG (muscle) signals.

It is also a platform for potential incorporation of temperature sensors, strain gauges, LEDs, solar cells, antennas etc. One expects that the cost of this technology will drop dramatically and will become widely available and used, including by biohackers.

Brain-to-computer interfacing

Interfacing directly to the human brain is certainly a target for biohackers but opening the skull is probably too extreme for even the most ardent of them (although the subject has certainly been discussed on biohacker forums).

Non-invasive external electrode attachment to read brainwaves is certainly within the scope of biohackers and a suitable device to do this would be from the Australian company Emotiv who make the EPOC+ EEG headset (see http://emotiv.com/). For further information on interfacing the brain, see Silicon Chip, "*Interfacing to the Brain*", Janu-

The Australian-made Emotiv EPOC+ EEG headset for reading brainwaves. Such a non-invasive device is suitable for biohackers interesting in interfacing to the brain and reading brainwaves (but not writing to the brain).

ary 2015 or www.siliconchip.com.au/Issue/2015/January/Interfacing+To+The+Brain

Synthetic Biology

Synthetic biology is a stream of biohacking (as well as a "mainstream" discipline) involving genetic experimentation with a philosophy of free and open-source access to information.

Do-it-yourself genetic engineering within minimal equipment such as in a biohacking workshop or laboratory (or even a garage or kitchen) is now feasible because of the ability to purchase custom designed or standard genetic sequences, the availability of "BioBricks" as standard genetic compoents (see below) and devices such as Open qPCR (see below).

To illustrate how powerful this field has become, consider that in 2008 a Nobel Prize was won "*for the discovery and development of the green fluorescent protein, gfp*".

This protein glows under UV light and has become a standard marker in biology. It represented many years of work, many scientists and state-of-the art-equipment.

It is now possible for DIY biohackers to insert the gene for this protein in an organism of their choice with minimal equipment and knowledge – and even do so in a kitchen laboratory.

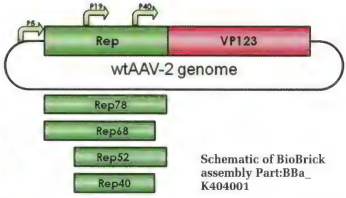
The number of biohacker projects in synthetic biology is large but for reasons of space only a few can be discussed here. We will discuss genetic building blocks that can be used by biohackers, a glow-in-the-dark plant project and a low-cost machine for genetic analysis.

Biobricks

Traditional genetic engineering involves the creation of genetic sequences that are unique and cannot easily be reused in different organisms and cannot easily be joined to other genetic sequences.

BioBricks are standardised genetic sequences for different biological functions that can be assembled by standard methodologies and joined to other BioBricks to make "biological circuits" which can then be inserted into bacteria such as E. coli to create organisms with new and novel functions.

The BioBrick catalog can be viewed at http://parts.igem.org/Main_Page and http://parts.igem.org/Catalog BioBrick



Schematic of BioBrick assembly Part:BBa_K404001

research and development comes under the auspices of the BioBricks Foundation (see below).

The glowing plant project

This is a biohacking project in which it is intended to insert genes from animals that glow in the dark, such as the bacteria in fireflies responsible for their night-time glow, into plants. The ultimate purpose of this is to create natural night time lighting. Imagine if all the trees in a street glowed at night! It would not be necessary to have electric street lighting.

The project was started by the BioCURIOUS hackerspace http://biocurious.org/ in California and funding was raised from Kickstarter. US$65,000 was sought but they raised US$484,000 instead!

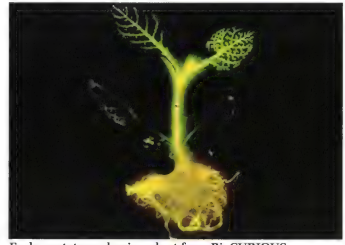
Information about the project can be seen at www.kickstarter.com/projects/antonyevans/glowing-plants-natural-lighting-with-no-electricit/posts/1225400

For the Kickstarter video on this project see "*Glowing Plant Kickstarter video*" https://youtu.be/YxFQ9MkwbDs

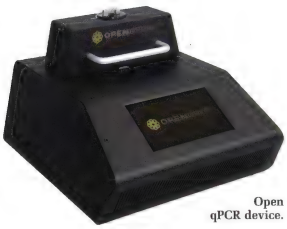
Open qPCR

The polymerase chain reaction created a revolution in biology when it was developed in 1983. It allows the copying of single pieces of DNA to an unlimited extent. qPCR stands for quantitative polymerase chain reaction and it allows for the determination of the presence of a specific DNA sequence of interest in a given sample.

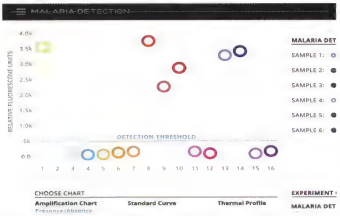
Open qPCR (www.chaibio.com) is a low cost open- source implementation of this technology that is well within the realm of biohackers.



Early prototype glowing plant from BioCURIOUS hackerspace.



Open qPCR device.



Screen from Open qPCR device showing test for malaria.

The Open qPCR device can detect pathogens, genetic mutations and dangerous diseases using DNA diagnostics.

Organisations and Communities

There are a lot of communities and organisations that work in support of biohacking. Some of these are as follows.

Australian groups

If you look at http://biohacking.meetup.com/ there are listings for biohacking groups in Sydney and Melbourne.

BioBricks Foundation

The BioBricks Foundation (http://biobricks.org) mission is "to ensure that the engineering of biology is conducted in an open and ethical manner to benefit all people and the planet. We believe fundamental scientific knowledge belongs to all of us and must be freely available for ethical, open innovation".

Biocurious

bioCURIOUS (http://biocurious.org/) is "a community of scientists, technologists, entrepreneurs and amateurs who believe that innovations in biology should be accessible, affordable, and open to everyone".

They have laboratory space in Sunnyvale, California. Among the past or present projects are a BioPrinter to "print" live cells using inkjet printer technology; a special microscope to enable the observation of living cells at high magnification and low levels of light (high levels of light tend to kill cells); a project in quantum biology – where physics meets biology; a project to engineer real vegan cheese without the use of any animals; projects in bioluminescence; biolab automation and robotics; the glowing plant project mentioned above; algae growing; development of synthetic biology tools and "bioart".

Biohack.me

Biohack.me (http://biohack.me) is an online community forum and Wiki for grinders from all over the world.

Counter Culture Labs

Counter Culture Labs (http://counterculturelabs.org) is "a community of scientists, tinkerers, biotech professionals, hackers, and citizen scientists who have banded together to create an open community lab — a hackerspace for DIY biology and citizen science". They are located in Oakland, California.

DIYbio.org

DIYbio describes itself as "an organization dedicated to making biology an accessible pursuit for citizen scientists, amateur biologists, and DIY biological engineers who value openness and safety".

Their website is at http://diybio.org/. There are DIYbio groups throughout the world including in Sydney, Melbourne and Auckland.

Genspace

Genspace (http://genspace.org) "is a nonprofit organization dedicated to promoting education in molecular biology for both children and adults. We work inside and outside of traditional settings, providing a safe, supportive environment for training and mentoring in biotechnology". They only work with safe Biosafety Level One organisms.

The International Genetically Engineered Machine (iGEM) Foundation

The iGEM (www.igem.org/Main_Page) is an international competition in synthetic biology open to students at all levels, entrepreneurs, community laboratories and others. Competitors are given a kit of standard biological genetic sequences, BioBricks from the Registry of Standard Biological Parts (see above) and the objective is to assemble these components into a living organism and have it express new or novel properties.

For a video of an interesting past project about the colour changing protein from squid called reflectin, see the segment starting at 20 min 57 seconds in the "Playing God" documentary referenced below. BioBricks have now been created to use this protein so it can be used as a standard component in future projects.

Science for the Masses

Science for the Masses (http://scienceforthemasses.org) is an independent biohacking community composed of professionals from a number of technical and scientific areas.

Quoting from them, their mission is to "to aid in the development of 'citizen science'; we want to see the tools and resources necessary to perform scientific research made available to anyone that wants them. To this end, all of our research is and will be published free and open source, and will be repeatable by the layperson—meaning no multimillion dollar lab equipment."

Among Science for the Masses' current or recent projects are the Human NIR project and administration of the drug chlorin e6 to enhance night vision described above.

Criticism of Synthetic Biology Biohacking

Synthetic biology as practised by biohackers has attracted some criticism, as it is feared that a biohacker might inadvertently create a dangerous toxin or organism, or worse, bioterrorists might deliberately do so.

This fear is countered by the fact that something suitable as a bioweapon is unlikely to be accidentally produced and that it would require advanced knowledge to produce such a weapon.

Such advanced knowledge already exists in the institutional laboratories of countries that promote terrorism and is accessible by terrorists so the point seems moot.

Conclusion

Biohacking is becoming more popular and more practical. The vast information dissemination capability of the Internet has ensured that the average citizen can participate in augmenting the human body and doing potentially advanced biology.

Something as simple as the insertion of a tiny magnet in a finger gives some people another sense. Other biohackers are trying much more ambitious implants.

In synthetic biology the discovery and development of the jellyfish green fluorescent protein won a Nobel prize in 2008. This protein can now be inserted into an organism in a kitchen laboratory by people with no significant scientific training. The advances are breathtaking.

The future is promising, access to huge amounts of data are readily available, supportive online communities exist and the future of biohacking seems bright as long as people continue to do the sensible and right thing. SC

A VIDEO TO WATCH

An interesting BBC Horizon documentary "Playing God" (http://watchdocumentary.org/watch/playing-god-video_fe8c719f5.html) talks about synthetic biology in general but also has a section on biohackers starting at around the 38 minute mark.

Biohacking smartphone apps

Biohacking doesn't have to involve external hardware, implants, chemistry or biology. Some biohacking involves "self quantification", that is, measuring some aspect of your body's performance and then improving it. There are many apps but a few randomly selected ones designed to improve your mental abilities are as follows:

Quantified Mind is a free app that was developed to measure such parameters as reaction time, executive function, verbal learning, motor skills, context switching, visual perception, short-term memory and many more. You can see what effect things like smart drugs, coffee or meditation have on your mind. See www.quantified-mind.com/.

Peak – Brain Training is an app which according to the developer "is a personalized self-improvement app specifically designed to help you train your Memory, Focus, Problem Solving, Mental Agility and Language skills with fun, challenging games, reaching goals and building healthy habits." See https://itunes.apple.com/us/app/peak-brain-training/id806223188?mt=8

BrainWars allows you to develop your mental abilities by competing against other people, either anonymous or ones you know. It is mainly intended to improve your concentration.

Available from Apple App Store or Google Play.

83x SuperZoom: Nik

Just a few years ago, who would have imagined a hand-held, fixed-lens digital camera which would offer a lens with the equivalent of 24mm to 2000mm, or 83x zoom? Professional photographer Kevin Poulter was so impressed with the new 16.1MP Nikon P900 . . . he bought one!

On one side we have "professional" DSLR cameras offering an enormous range of features, not the least being the range of lenses available. Coupled with this are prices that range into the stratosphere. On the other side are "consumer" models, with a single fixed lens and often little, if any, user controls apart from a shutter button.

They became known as "point and shoot" models – and they've only been superseded, to some degree, by the amazing quality of some cameras found in today's smartphones.

But in between the two came the "prosumer" models; cameras which for not too much money could turn the average holiday snapper into a fine photographer, if only because the camera managed to do most of the tricky stuff itself.

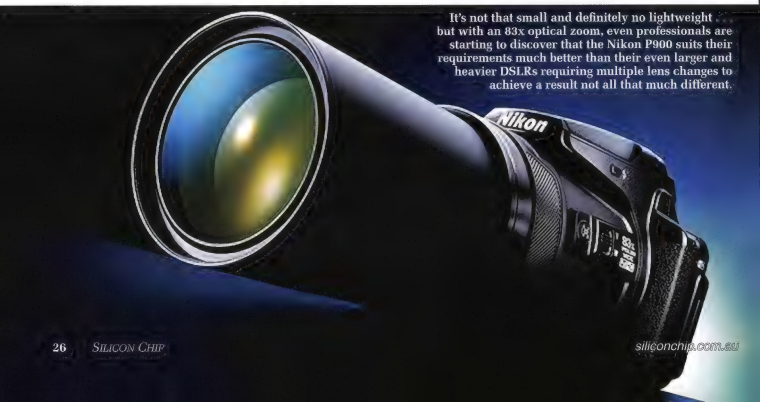
It's into this genre that the recently released Nikon P900 fits – but with features definitely leaning towards the professional side, rather than the consumer . . . and the price is very much in favour of the consumer!

Digital photography is constantly evolving and electronics is the driving force. With a proliferation of brands and camera models, consumers look for major advancements, especially cameras that virtually take the photographs for them. Optics have nearly peaked in features, quality and affordability, so electronics leads the way.

For example, there are cameras with GPS satellite connection to location-stamp photographs. Or a viewfinder screen that displays on almost any angle, then automatically switches to the eye-level viewfinder when approached by the user's eye. And so on.

SuperZoom cameras

Fixed-lens SuperZoom cameras challenge DSLRs as they offer fantastic versatility, compact size and most of all, the capability of photographing wide angle scenes – and then being able to "zoom in" to very distant vistas; ***very*** distant vistas, as the series above ably demonstrates!



It's not that small and definitely no lightweight . . . but with an 83x optical zoom, even professionals are starting to discover that the Nikon P900 suits their requirements much better than their even larger and heavier DSLRs requiring multiple lens changes to achieve a result not all that much different.

Words and photos by Kevin Poulter

on's incredible P900

Digital cameras now enable almost anyone to photograph at near-professional standard and send photographs anywhere in the world in moments.

In addition to the size and zoom, fixed lens digital cameras abolish the need to change lenses, a difficult task outdoors, especially if there are environmental factors in play, like sun, dust or salt spray enhanced air.

Extraordinary advances in digital imaging

Not long after digital cameras arrived, I saw the possibilities and started to use an Olympus fixed lens digital camera.

At first some magazines refused to accept digital camera images, as they often reproduced very poorly compared to drum-scanned slides (transparencies), plus major colour errors like purple skies often appeared in the printing reproduction process.

So I enhanced and colour-corrected my digital images manually in Photoshop set to CMYK colour mode, didn't mention their digital origins and then saw my digital images regularly in Australian magazines. I felt especially vindicated when an enhanced 4MP image of a car interior was reproduced full page in a glossy magazine and it looked perfect.

Lens quality and range

You often hear "experts" deride fixed-lens zooms: "you can't get the same quality as you can with interchangeable lenses".

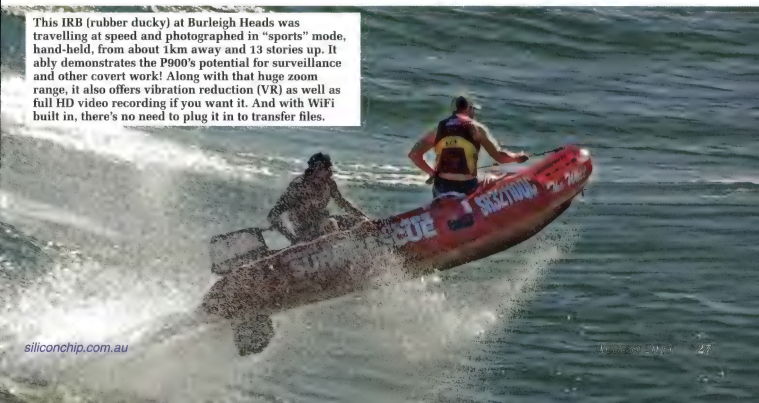
Perhaps that is a consideration; however most P900 images are very good and can be enhanced in software like Photoshop Elements for startling improvements, so the images from the leading fixed lens cameras (FLC) suit enlarging or magazine reproduction.

Of course if you look very closely, you might see a difference between a $10,000 telephoto lens and a <$1,000 FLC camera's image but it's hard to beat the FLC's features: smaller, easier to use and carry, vastly more economical and very acceptable images.

The Nikon P900 enabled ticking off a number of long-term photo goals in my bucket-list – extreme macro, surfers riding the waves and other distant photography like birds (feathered type) and a portable semi-professional (prosumer) camera that would fit in a very small bag and be ready for action in seconds.

Professionals might still use a DSLR, but the P900 compact SuperZoom Nikon is *so* portable when highest standard resolution is not needed.

At 83x zoom (or the equivalent of 24mm to 2,000mm in the old film format), photographers can produce many photographs that were previously out of reach.



This IRB (rubber ducky) at Burleigh Heads was travelling at speed and photographed in "sports" mode, hand-held, from about 1km away and 13 stories up. It ably demonstrates the P900's potential for surveillance and other covert work! Along with that huge zoom range, it also offers vibration reduction (VR) as well as full HD video recording if you want it. And with WiFi built in, there's no need to plug it in to transfer files.

For example see the Surf Club rubber ducky shown below, photographed from about a kilometre away. This sensational magnification makes the P900 very suited for surveillance use, like Police and ASIO.

On top of the optical zoom of the lens itself, digital zoom is also available (electronic magnification), taking the zoom capability to a startling 8,000mm equivalent!

However, digital zoom is not recommended, as despite some processing enhancement in the camera, it also magnifies any lack of clarity and noise by four times.

The best method for achieving images beyond 83x is to photograph at full optical zoom and crop plus enhance later in a computer.

The Nikon P900 showing one of the many angles the monitor can be set to for viewing, including aiming at the subject, for selfies. When tilted toward the base, the camera can be held high for photographs over the heads of people in a crowd.

Electronics leads the way

Advances in electronics have added so many features, like image processing, non-optical viewfinder screens (including eye-level), high-capacity small batteries, massive storage cards and much more.

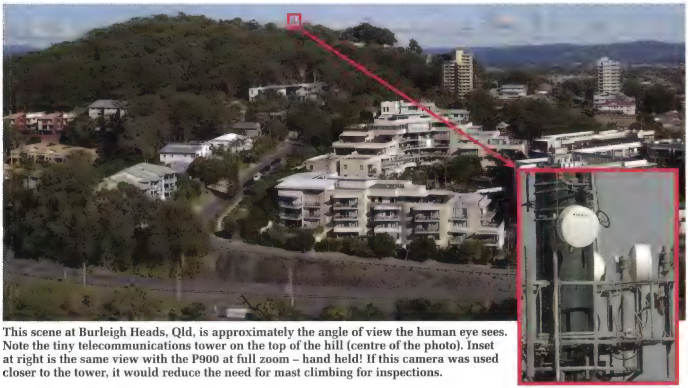
Apart from the SuperZoom, one of the most attention-getting features of the P900 is the IR auto-sensor that detects the eye approaching the eyepiece viewfinder and switches to that display. This not only saves a huge amount of power compared to simultaneously running two screens, it's much more convenient than manual switching.

Strictly speaking the IR does not detect the person's eye, rather anything that comes in range of the eyepiece (for example, waving a hand). First reaction is "what? how does it know it's your eye?", then you realise the IR can be activated by any solid object.

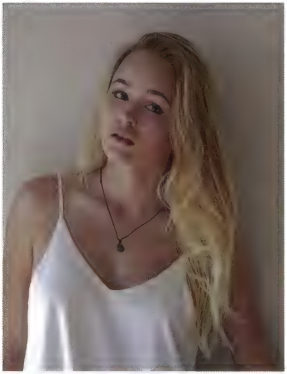
Vibration reduction

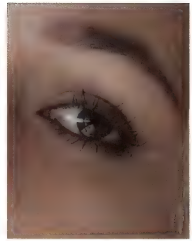
Another most useful and wow-factor electronics-driven feature is the Vibration Reduction (VR) or anti-shake system. Nikon's is arguably the best - certainly it's nothing short of spectacular. The vibration reduction is so good, it's possible to take a photo of the moon hand-held with only a moderate loss of clarity compared to on-tripod photography! It works by electronic motion feedback to a VR "floating" interior lens element, which follows your movement perfectly.

The new Dual-Detect Optical VR system in the P900 utilises accelerometers in the lens, linked to analysing image motion on the sensor, with a claimed five stops worth of stabilisation. In other words, you get 32 times as much light on the sensor as you would without VR!



This scene at Burleigh Heads, Qld, is approximately the angle of view the human eye sees. Note the tiny telecommunications tower on the top of the hill (centre of the photo). Inset at right is the same view with the P900 at full zoom – hand held! If this camera was used closer to the tower, it would reduce the need for mast climbing for inspections.





The eyes have it! Check out the two pictures above: which one do you think was taken with the P900?
The photo at left of Natyse shows the lens angle of view and enlargement used for the highly magnified test at its right, a huge enlargement of the same photograph. Two images were taken with the same zoom magnification, on two cameras. The startling result shows the P900 image (left) has better clarity than a Canon EOS 60D SLR with a Canon 18-55mm lens! If it wasn't for the lack of a "hot shoe" (flash adaptor) on the Nikon P900, I would leave the Canon at home more often and shoot everything with the Nikon!

The VR System works by driving motors moving an internal lens element, to compensate for camera shake. Two angular velocity sensors are used, one detects "pitching" (vertical movement), while the other detects "yawing" (horizontal movement).

Diagonal movements are detected by an amalgamation of the results of both sensors. These sensors detect camera movement as angular velocity every millisecond. Angular velocity data is sent to a microcomputer (built in the lens) which calculates the amount of compensation needed. Then data is transmitted to the VR unit and adjustments are made instantaneously.

Commands are sent to two voice coil motors (VCMs), which move the VR lens in a particular direction. Nikon's VR System changes operation algorithms when the shutter release button is lightly pressed and during exposure.

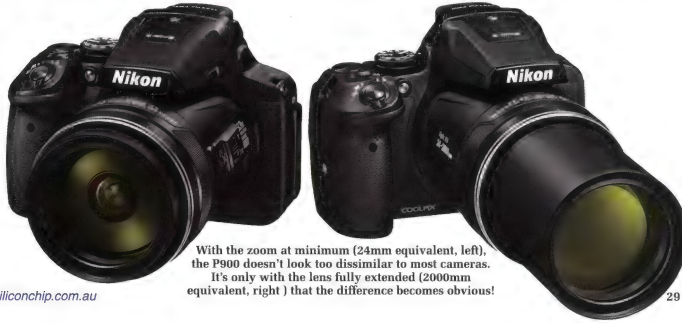
Therefore when the shutter release button is lightly pressed, the VR lens shows a smooth viewfinder image. During the exposure, however, the algorithm changes to compensate for every slight movement. Furthermore, just before exposure, in a Nikon exclusive, the VR lens will reset to the central position, to ensure maximum range of movement on all axes. One unexpected point is the VR must be switched off when using a tripod, or results may not be perfect.

Manual mode or the pre-set "Moon Mode" is great for photographing our nearest neighbour in space.

Tips: to achieve the best hand-held images at high zoom, brace your elbows hard to your side and set the camera into burst mode. Then examine the resultant images. Chances are one image will be clearer than others. Incidentally, a full moon does not show as much detail as a partial phase.

Image Sensor

The CMOS 1/2.3-inch (6.2mm x 4.6mm) sensor has 16.1 million effective pixels, which are reduced in some modes like burst. Pixel-count is a guide to quality, however how a



With the zoom at minimum (24mm equivalent, left), the P900 doesn't look too dissimilar to most cameras. It's only with the lens fully extended (2000mm equivalent, right) that the difference becomes obvious!

sensor is designed, its size and type, lens, plus in-camera processing are the ultimate tests of image quality.

Suffice to say the P900 images are well suited for most amateur applications and many less-demanding professional applications.

The P900 is able to shoot a burst at up to seven frames per second in full resolution. The shooting lag for a single-shot is measured by Nikon as approximately 0.12 seconds at wide angle and .75s at telephoto, both excellent figures.

Remember early digital cameras and the delay between pressing the shutter release and the image being captured? In many it was more than a second (often the photo opportunity had disappeared by then – or the subject had seen you aim the camera and turned away!).

The P900 records in JPEG compressed format which can be near lossless with few artifacts in fine mode. RAW is not supported (another oft-heard "professional" criticism), though not many prosumer photographers nor computer processing applications need that unprocessed mode.

Video

Many still cameras now film HD (or even 4K) video, taking advantage of the comparatively large sensor size. Video is filmed very well - better than most professional video cameras achieved just a few years ago.

The P900's in-built microphone audio in video mode is very sensitive, but includes accentuated background noise like birds, so if you are serious about video, look for a camera with mic input. Nikon has a microphone zoom mode, which reduces background noise somewhat.

Full HD recording is 50 frames per second or 25 fps in PAL mode. Slow-mo is available and videos are recorded using the H.264 standard in an MPEG-4 container with stereo audio.

Snapbridge enables easy sending of photos from a Nikon WiFi and NFC enabled camera to compatible smartphones or tablets. Or use a Smartphone or Tablet to control your camera.

WiFi

Nikon's P900 has both WiFi and NFC connectivity for Nikon's Snapbridge smartphone companion app. The Nikon P900 enables wireless transfer of images to a compatible smartphone or tablet for quick and easy sharing or mobile post-processing, however the Snapbridge app can also be used as a wireless remote control for even more creative possibilities. (Nikon's optional ML-L3 infrared remote is also supported.) The Coolpix P900 also includes a built-in GPS to geo-tag your photos during your travels.

Global Positioning

GPS and Points of Interest (POI) are built-in, recording the exact location of each shot you take, so you can recall where photographs were taken. Your journeys can be shared on Google Maps, Google+, and other social networking sites, or with Nikon View NX2 software. Points of Interest (POI) show nearby photo-ops like scenic lookouts and historic landmarks.

AutoFocus (AF)

AutoFocus is the contrast-detect type, so occasionally it will not focus on a flat plane surface but mostly it's very good. The focus area selection can be Face priority, Manual (spot, Normal or Wide), subject tracking or Target-finding.

Other features

These include highlight a single colour in a black & white photo. Create portraits that look like paintings and illustrations. Combine multiple exposures into one high dynamic range image for best shadow and highlight detail and more in the camera.

The rechargeable lithium-ion battery is 3.8 volts DC and 1850mAh, good for about 360 photographs per charge or 1 hour 20 minutes of video.

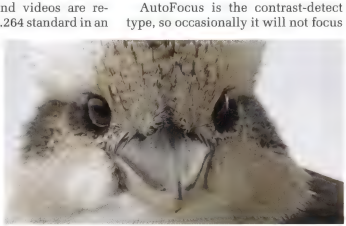
Memory Card

The P900 accepts cards up to 32GB in SDHC type, or up to 128GB in SDXC types. Nikon has only tested SanDisk, Toshiba, Panasonic and Lexar cards, so check the on-line handbook before investing in one. I recommend a 32GB memory card, as most people can save about 3,000+ images on that capacity, or a number of years of images. So it's important to download them regularly to your computer as back-up.

Choose the fastest and largest capacity well-known-brand memory card within your budget. The card should be rated at class 10 speed if possible, especially for fast burst image loading and video. A card rated less than class 6 may cause video to stop unexpectedly.

The less important figure is 30MB/s, the download transfer speed to a computer.

Look for sale prices offering 32GB rating 10 cards – we've seen recognised brands as low as 50c per gigabyte (but see the "SD card Scam" panel – don't



With the P900 long lens and macro setting, both wildlife and photographer are relaxed. The macro setting enables photography to within millimetres of the front lens element.

buy on price alone).

It's important to format the card *in the camera* before use to suit the individual camera, or you may think it's working but lose all images.

Essential accessories

While the P900 comes with most of the "accessories" you need inbuilt, it doesn't include everything. For instance, all cameras (not just this one!) should have the best quality UV filter you can afford on the front of the lens. Just like adding top quality speakers to an amplifier, the camera lens should not be compromised by a cheap filter.

We chose a Hoya 67mm HD UV Ultra premium digital filter, purchased from a local supplier for $65 posted, via ebay - about half retail price. The added filter ensures the lens isn't scratched in an accident and if it becomes dirty, only the filter is contaminated or damaged.

Incidentally, if the filter is affected by salt from a boating trip or a visit to the beach, it needs to be washed with a very soft cloth in fresh water. Just rubbing salt off with a soft cloth is extremely abrasive and the filter will be scratched.

A lens hood is not essential, but saves sun glare entering the lens and protects the lens if it gets close to a hard surface, like a window. A 3-stage rubber collapsing lens hood needs to have an internal thread so the lens cap can be in place when not in use. This feature is rare. We chose a Phottix 67mm 3-Stage Collapsible Rubber hood, again on ebay from a local supplier, at $27 posted.

There's slight vignetting or small dark areas in the image corners on wide-angle, but that's rarely a problem and the hood can be taken off. There's no indication that a wider rubber lens hood is available.

How does the P900 rate?

It's big – as large as some SLR cameras – and heavy, at 900 grams with battery, card and shoulder strap.

It's also quite pricey (especially if you pay the RRP of almost $900!). shopbot.com.au suggests prices from about $620 up.

There's just a few glitches that were also in the earlier compact P510, like the lens occasionally fully extending without a request to do so, but rarely enough to be concerned about.

To support Australian bricks and mortar stores, the P900 in this review was purchased from a Ted's Camera store. Within a week the camera had lost some functions and Nikon said it needed a firmware re-load.

However, when I took the P900 back to Ted's, they replaced it on the spot. So it pays to go to a reputable supplier, underscored by previously having a Canon repaired by Teds under an extended warranty. In a short time it was repaired and available to pick up with no cost. Imagine getting that sort of service via ebay!

There's much more to the P900 and that's why the manual is 242 pages, but these are the highlights. At a street price of $680, the Nikon P900 comes highly recommended, or for real portability with a less ambitious SuperZoom, consider the Nikon P610 with 60x zoom, priced at $499, the very small Nikon Coolpix L830 with 30x zoom at $199, or other leading camera brands.

Summary

Does every photographer need an 83 times zoom lens camera? No, but it sure is fun when you have exhausted most other photo opportunities. There may be practical business applications too, like inspecting power lines, insulators, aerial arrays and surveillance.

If you'd like a small portable SuperZoom camera, the P610 or similar is so easy to carry and use – even one handed. You will still be able to photograph the moon near full-frame, but the lightweight compact convenience is a real plus.

Your choice can be assisted by a visit to a comparison website, such as http://goo.gl/u1kERf

All websites may have a bias or sales agenda but it's a great starting point. Type in the two cameras that you want compared and immediately see the major differences and advantages of one camera over the other.

Ultimately your choice of camera depends on what features you want most of all and how much you really can afford! SC

Beware the SD Card Con!

Before ordering an apparently "bargain" SD on line (particularly from overseas) use your friend Dr Google and search for "fake SD cards" or similar. Some reports suggest that as many as 80% of higher-capacity cards are fakes (even some with apparently legitimate labels) and are very much lower capacity than shown (would you believe 8-16MB?) with "spoof" software to make them appear larger.

It would appear that fake 32GB cards are the fraudster's "sweet spot" although other sizes do rate a mention. There are several utilities available on the web which will check a suspect card and tell you if it's the real deal. But, if you'll excuse one more cliché . . . if it sounds too good to be true, it probably is!

For comparison, here's the Nikon P900 (centre) shown alongside a Canon EOS 60D and a smaller Nikon P510.

Ultra-LD Mk.4 200W RMS Power Amplifier Module, Pt.1

By NICHOLAS VINEN

This is our latest and best-performing amplifier module yet. Not only have we reduced the distortion compared to the Mk.3 version but it's now smaller and has more features – LED indicators for the supply rails and for blown fuses, output offset voltage nulling, flyback diodes for the output stage and a LED clipping indicator. This month we have a detailed description of how it works.

Specifications

Output power (230VAC mains): 200W RMS into 4Ω, 135W RMS into 8Ω
Frequency response (10Hz-20kHz): +0,-0.05dB (8Ω); +0,-0.12dB (4Ω); see Fig.5
Input sensitivity: 1.26V RMS for 135W into 8Ω; 1.08V RMS for 200W into 4Ω
Input impedance: 11.85kΩ shunted with 1nF
Rated Harmonic Distortion (4Ω, 8Ω): <0.001%, 20Hz-20kHz, 20Hz-30kHz bandwidth; see Figs.3 & 4
Signal-to-Noise Ratio: -124dB unweighted with respect to 135W into 8Ω (20Hz-20kHz)
Damping factor: ~250
Stability: unconditionally stable with any nominal speaker load ≥4Ω
Music power: 170W (8Ω), 270W (4Ω)
Dynamic headroom: 1dB (8Ω), 1.3dB (4Ω)
Power supply: ±57V DC from a 45-0-45 transformer
Quiescent current: 140mA nominal
Quiescent power: 16W nominal
Output offset: typically <10mV untrimmed; <1mV trimmed

Main Features

- Low distortion and noise
- Able to produce specified power output on a continuous basis with passive cooling
- Compact PCB
- Onboard DC fuses
- Output offset voltage adjustment
- Output protection diodes (for driving 100V line transformers & electrostatic speakers)
- Power indicator LEDs
- Fuse & power status indicator LEDs
- Clipping indicator LED
- Clean overload recovery with low ringing
- Clean square wave response with low ringing
- Tolerant of hum & EMI fields
- Survives brief short circuits & overload without blowing fuses
- Quiescent current adjustment with temperature compensation

AS EXPLAINED in the preview last month, this revised amplifier module has lower distortion than the Mk.3 version. It's also somewhat smaller and uses more modern parts that are easier to get.

We haven't called this amplifier series "Ultra-LD" for nothing. The Mk.3 version already had extremely low distortion levels of well under 0.001% up to a few kilohertz and just 0.002% at 10kHz. Very few commercial amplifiers would beat that. We've really had to work hard to do better but we have – check the performance graphs to see for yourself.

In fact, the distortion of this amplifier module is so low that we've had to develop new testing techniques just to measure it. We found that the resistive load that we've used to test amplifiers for years simply wasn't linear enough. Even with this module running near maximum power, the distortion level across pretty much all of the audible frequency range is less than 0.001%. That's fewer than 10 parts per million!

Since publishing the preview, we've made further improvements to the performance and added a few features. These include onboard LEDs which indicate if the power rails are present and which change colour if the DC fuses blow. We've also added a clip indicator circuit which drives a LED to show when the amplifier is being overdriven. This LED can be mounted on the amplifier front panel if desired and can be wired to multiple modules to indicate when any channel is clipping.

The power output is the same as before: 135W RMS continuous into 8Ω and 200W into 4Ω, with higher music power (short term) figures of 170W for 8Ω and 270W for 4Ω. These are measured using the IHF standard of 20ms high-power bursts interspersed with 480ms of -20dB output (ie, two bursts per second). These equate to a dynamic headroom of 1dB for 8-ohm loads and 1.3dB for 4-ohm loads.

WARNING!

High DC voltages (ie, ±57V) are present on this amplifier module when power is applied. **In particular, note that there is 114V DC between the two supply rails.** Do not touch the supply wiring (including the fuseholders) when the amplifier is operating, otherwise you could get a lethal shock.

Circuit description

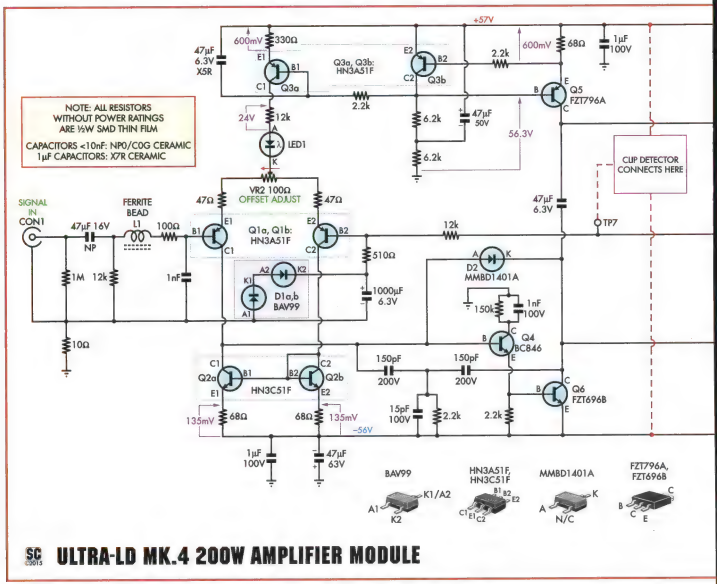
Let's take a look at the operation of the Ultra-LD Mk.4 Amplifier module circuit now; we'll go over the changes later. The circuit is shown in Fig.1.

A 1MΩ resistor DC biases the input signal at RCA socket CON1 to 0V. The signal ground (ie, RCA socket shield) is connected to power ground via a 10Ω resistor, which improves stereo separation when modules share a power supply; it prevents a ground loop due to the grounds being joined directly both at the power supply module and at the signal source.

The signal passes through an RF-attenuating RC low-pass filter (100Ω/1nF plus ferrite bead) and is then coupled to the base of PNP transistor Q1a via a 47μF DC-blocking non-polarised electrolytic capacitor; a 12kΩ resistor provides a path for Q1a's base current.

Low-noise PNP input transistors Q1a and Q1b are in the same SMD package. The input signal goes to the base of Q1a while feedback from the output goes to the base of Q1b. Both transistors have 47Ω emitter degeneration resistors for improved linearity and they are fed with a common 2mA current via trimpot VR2, power indicator LED1 and a 12kΩ voltage dropping resistor.

VR2 allows the current split to be shifted slightly between the two transistors, to trim out base-emitter voltage mismatch and thus practically eliminate any output offset, to avoid excessive DC current when driving a line transformer or electrostatic speaker. The 12kΩ resistor reduces dissipation in Q1a/Q1b and also acts as a fail-safe to allow the amplifier to operate more or less normally even if Q3a or an associated component fails. LED1 has no



SC 03015

ULTRA-LD MK.4 200W AMPLIFIER MODULE

Fig.1: the complete circuit for the Ultra-LD Mk.4 amplifier module, minus the clip detection circuitry which is shown separately in Fig.2. Q1a & Q1b are the input transistors (housed in a single package) while Q2a/Q2b form the current mirror and Q3a the constant current source. Current drive then flows to a VAS Darlington comprising Q4 & Q6, with a constant current load supplied by Q5. Bias for the output stage is generated by diodes DQ10-DQ13 which are integral to the output transistors, plus V_{BE} multiplier Q9 which is adjusted using trimpot VR1. Driver transistors Q7 & Q8 then supply base current for output transistors Q10-Q13 which are connected to the loadspeaker load via 0.1Ω emitter resistors and an RLC filter consisting of air-cored inductor L1, four parallel 27Ω resistors and a 100nF capacitor.

effect on the operation of the circuit except to indicate when it is powered.

The currents from Q1a and Q1b go to a current mirror comprising NPN transistors Q2a and Q2b, also in a single SMD package. The 68Ω emitter resistors help ensure that equal current flows through each transistor as the voltage across these resistors is much greater than the base-emitter voltage difference between the two.

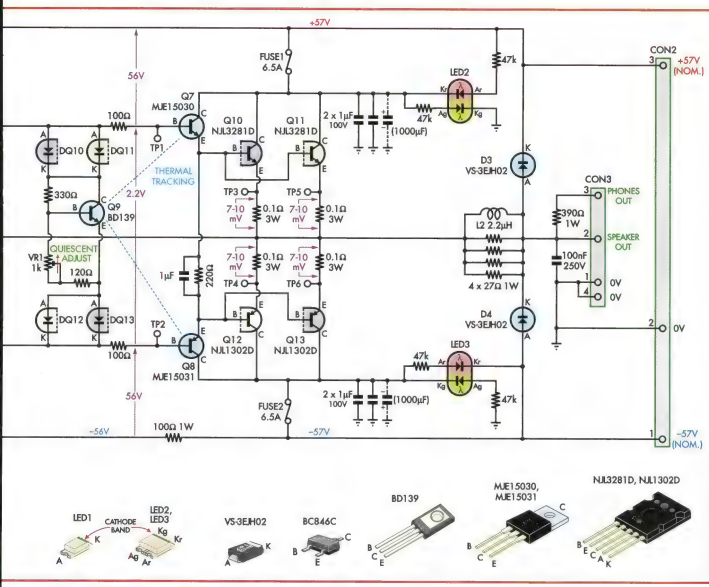
Since current through Q2a and Q2b is held equal, any difference between the current from Q1a and Q1b must flow to the base of NPN transistor Q4. Thus, Q4's base current is proportional to the difference in input and feedback voltages. It forms the first half of a Darlington pair along with Q6, a 250V high-gain transistor. A 2.2kΩ resistor between its base and emitter speeds up switch-off.

Q4 and Q6 together form the Voltage Amplification Stage (VAS); Q6 has a constant current collector load and as a result, the current flow to its base is translated linearly to a voltage at its collector which controls the output stage.

Output stage

The output stage consists of two pairs of power transistors arranged as complementary emitter-followers. NPN transistors Q10 and Q11 are connected in parallel and source current for the load while Q12 and Q13 are PNP types and sink current from the load. 0.1Ω emitter resistors ensure equal current sharing, linearise the output stage and reduce local feedback. They also serve as handy shunts for measuring the quiescent current.

Large power transistors require a substantial base current due to limited gain and this is supplied by driver transistors Q7 and Q8. Effectively, this makes the output stage a complementary Darlington. The parallel 220Ω re-



sistor and 1µF capacitor between the driver emitters speed up switch-off when drive is being handed off from one to the other.

The four base-emitter junctions in the output stage, plus the voltage across the emitter resistors adds up to around 2.2V and thus a similar DC bias must be maintained between the bases of Q7 and Q8 to keep the output transistors in partial conduction most of the time. Otherwise, there will be substantial crossover distortion each time the signal passes through 0V.

However, the base-emitter voltages of these six transistors vary with temperature so a fixed DC bias is not suitable. Since the base-emitter voltages drop with increasing temperature, a fixed bias voltage would lead to increased current as the transistors heated up and ultimately, to thermal runaway and destruction.

So the DC bias is generated by diodes DQ10-DQ13 and transistor Q9. DQ10-DQ13 are internal to output transistors Q10-Q13 so their temperatures track well and as a result, their forward voltage drops as the output transistors heat up. These are connected in two parallel pairs – just like the output transistors – for accurate temperature compensation.

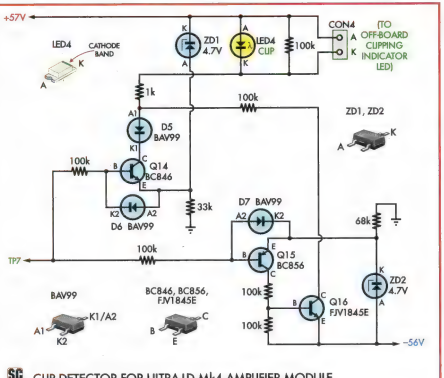
V_{BE} multiplier

Similarly, NPN transistor Q9 is mounted on the heatsink immediately between Q7 and Q8 so it also tracks their temperatures quite well. It forms an adjustable V_{BE} multiplier with a collector-emitter voltage equal to its temperature-dependent base-emitter voltage multiplied by the ratio of the resistive divider across it. Thus, VR1 controls the quiescent current.

The bottom end of the bias network is driven directly by VAS transistor Q6 and the voltage swing is coupled to the top of the network by a 47µF capacitor. Operating current for this network is fixed at 10mA by PNP transistor Q5. The 100Ω resistors between either end of the DC bias network and Q7/Q8 act as RF stoppers and also limit current flow under fault conditions (eg, a short circuit).

Q5 is able to hold the VAS/bias current constant at around 10mA because its base is driven by Q3b to maintain around 0.6V across its 68Ω emitter resistor. Should this voltage increase, Q3b turns on harder, increasing the current through the two 6.2kΩ resistors and thus reducing the current from Q5's base, reducing its emitter current. Similarly, if the voltage across the 68Ω resistor drops, Q3b allows Q5 to turn on harder to compensate.

The 47µF capacitor at the junction



SC 2010 CLIP DETECTOR FOR ULTRA-LD Mk4 AMPLIFIER MODULE

Fig.2: the clip detector monitors the waveform at feedback point TP7 relative to the supply rails and pulls ~1mA through LED4 whenever the output voltage comes within approximately 4V of either rail, indicating the onset of clipping. NPN transistor Q14 detects positive excursions while PNP transistor Q15 detects when the output approaches the negative rail and its output is level-shifted by NPN transistor Q16 to light the same LED.

of the 6.2kΩ resistors virtually eliminates variations in the current through them with supply voltage, stabilising Q5's current regulation. Q5's base bias voltage is also fed to Q3a via an RC low-pass filter (2.2kΩ/47μF), which in combination with the 330Ω emitter resistor, sets the current from Q3a to the input pair to 2mA.

Feedback & compensation

Feedback goes from the junction of the output emitter resistors to the base of Q1b via a 12kΩ/510Ω resistive divider, setting the closed loop gain to 24.5x (28dB).

The bottom end of the feedback network is connected to ground via a 1000μF electrolytic capacitor. This has a negligible effect on low-frequency response but sets the DC gain to unity, so that the input offset is not magnified at the output by the gain factor of 24.5.

The compensation network is connected between the collector of Q6 and the base of Q4, ie, it is effectively a Miller capacitor for the VAS Darlington. The junction of the two series 150pF capacitors connects to the negative rail via a parallel network comprising a 2.2kΩ resistor and 15pF capacitor. This is a form of two-pole compensation which avoids rolling off the open loop gain until higher frequencies, thus yielding better distortion performance; this was explained in more detail in the July 2011 issue, on page 34.

We've added the 15pF capacitor since it improves overall stability, by providing a small "third-pole" compensation characteristic. The 1nF capacitor across Q4's collector similarly improves stability, for reasons explained below.

The 150kΩ resistor limits the current through Q6 under fault conditions. Should the amplifier outputs be shorted, it will try to pull the output either up or down as hard as possible, depending on the offset voltage polarity. If it tries to pull it up, the output current is inherently limited by the ~10mA current source driving Q7 from Q5. However, if it tries to pull down, Q6 is capable of sinking much more current.

The 150kΩ resistor limits Q6's base current to around 150μA and thus Q6's collector will not sink much more than 100mA. This is probably still enough to burn out Q8's 100Ω base resistor but that may be the only damage from an extended short circuit; very brief short circuits will should not cause any lasting damage.

However, this resistor will cause Q4's collector voltage to drop as it is called on to supply more current and the Early effect means its gain will drop when this happens. This can cause local negative feedback and oscillation. A low-value capacitor in parallel with the 150kΩ resistor prevents this while still allowing the current to Q6's base to quickly drop below 1mA during a short circuit.

Output filter

The emitter resistors of output transistors Q10-Q13 are connected to the output at CON2 via an RLC filter comprising a 2.2μH series inductor in parallel with a 6.8Ω resistance (4 x 27Ω in parallel), with a 100nF capacitor across the output terminals.

The inductor isolates any added capacitance at the output (eg, from the cables or the speaker's crossover network) from the amplifier at high frequencies, which could otherwise cause oscillation. The resistor reduces the inductor's Q, to damp ringing and also forms a Zobel network in combination with the 100nF capacitor, which also aids stability.

Driving a line transformer

While a very low output offset voltage gives slight benefits when driving normal speakers, it's absolutely critical when driving a 100V line transformer or electrostatic speaker (which will typically have an internal transformer). That's because the DC resistance of the primary winding will be much lower than that of a loudspeaker's voice coil, so a lot of DC current can flow with an offset voltage of just a few millivolts.

The other requirement for driving a transformer is to have protection diodes on the amplifier output to clamp inductive voltage spikes which occur when the amplifier is driven into clipping (overload). These would otherwise reverse-bias the output transistor collector-emitter junctions, possibly causing damage. D3 and D4 are 3A ultrafast, soft-recovery diodes with low junction capacitance for their size and we have checked that they do not have any impact on performance.

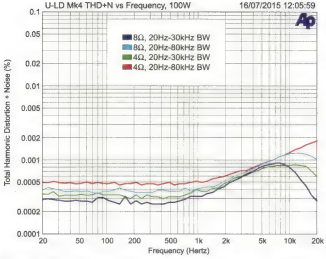


Fig.3: THD+N when driving resistive loads at 100W. It's so low, it's really pushing our ability to measure distortion with the equipment that we have. 4Ω performance is usually worse than 8Ω but in this case, not by much!

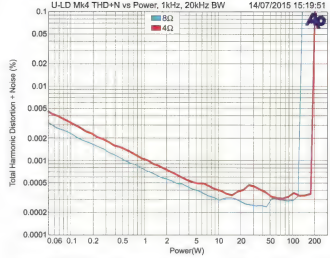


Fig.4: THD+N, this time showing how it varies with power at a fixed frequency. It's dominated by noise below 10W and is very low until the amplifier starts to run into clipping at 135W for 8Ω loads and 200W for 4Ω loads.

So there should be no changes necessary to use this module in a PA amplifier or to drive electrostatic speakers, as long as the output offset voltage is trimmed out during set-up.

Indicator LEDs

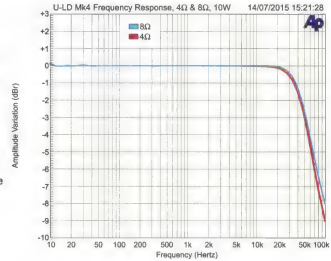
While producing the final PCB design, we decided to use some of the spare real estate to add indicator LEDs. LED1 (blue) is connected in series with the input pair current source and is on while ever the board has power applied. Since there is an ~50V drop required from Q3a's collector to VR2's wiper, the power to operate this LED is effectively free.

We've also added red/green LEDs LED2 & LED3 to indicate the status of the output stage power rails. It isn't always obvious that a fuse has blown without careful inspection.

In the case of LED2, assuming F1 has not blown, the voltage at either end of the fuseholder is the same so no current will flow through the red junction. However, the green junction is connected between the collectors of Q10/Q11 and ground via a 47kΩ current-limiting resistor, so it will light up. Should the fuse blow, the collector voltages will drop to near 0V, so the green LED will turn off but the full rail voltage will be across the fuseholder and so the red junction will switch on.

Similarly, LED3 indicates green/red when F2 is OK/blown. These LEDs will also indicate if one of the two supply rails is missing (eg, due to a wiring fault); in this case, LED1 will probably still light up so it might not otherwise be obvious.

Fig.5: frequency response is very flat for 4-8Ω loads, with no detectable roll-off at the low-frequency end and only about one tenth of a decibel by 20kHz at the high-frequency end. Most of the high-frequency roll-off is due to the necessary output filter.



Clipping indicators

We've also added an on-board clipping detector/indicator circuit. This involves just a few components and allows you to quickly see if the amplifier is overloaded; sometimes moderate clipping is not obviously audible. It can drive an external LED mounted on the front panel of the amplifier. These components may be omitted if they are not required.

The clip detector circuit is shown in Fig.2. Zener diode ZD1 derives a reference voltage 4.7V below the nominally 57V positive rail, ie, at about 52V. This is connected to the emitter of NPN transistor Q14. Its base is connected to the amplifier output via a 100kΩ current-limiting resistor, with diode D6 preventing its base-emitter junction from being reverse-biased.

At the onset of clipping, the speaker voltage will rise above the reference voltage plus Q14's base-emitter voltage, ie, to about 53V. Q14 will switch on and sink current via LED4, a 4.7kΩ current-limiting resistor and isolating diode D5, lighting up the clip indicator LED. As the reference voltage is relative to the positive rail, any variations in supply voltage will be accounted for.

ZD2, PNP transistor Q15 and diode D7 work in an identical manner for negative excursions. However, Q15 drives LED4 via high-voltage NPN transistor Q16 which acts as a level shifter. The 100kΩ resistor in series with its collector limits the LED current to a similar level (1mA) despite the much

Parts List: Ultra-LD Mk.4 Power Amplifier

1 double-sided PCB, code 01107151, 135 x 93mm
1 black anodised aluminium heatsink, 200 x 75 x 45mm (L x H x D)
2 SMD M205 fuse clip assemblies (F1, F2) (Digi-Key F4546-ND)
2 6.5A M205 fast-blow fuses (F1, F2)
2 blown M205 fuses (for testing)
1 SMD 3216/1206 ferrite bead (L1)
1 2.2μH air-cored inductor (L2) (or 1 20mm OD x 10mm ID x 8mm bobbin and 1m of 1.25mm diameter enamelled copper wire, plus 10mm length of 20mm diameter heatshrink tubing)
1 1kΩ vertical multi-turn trimpot (VR1)
1 100Ω SMD single-turn trimpot, EVM1D type (VR2) (Digi-Key P1D101TR-ND)
4 TO-264 or TOP-3 silicone insulating washers
2 TO-220 silicone insulating washers
1 TO-126/TO-225 silicone insulating washer (or a TO-220 washer cut down)
2 transistor insulating bushes
7 PC stakes (optional)

Screws, nuts, spacers & washers

4 M3 x 9mm tapped spacers
7 M3 x 20mm machine screws
8 M3 x 6mm machine screws
7 M3 nuts
7 M3 flat washers

Connectors

1 vertical mounting RCA socket (CON1)
1 4-way vertical pluggable terminal block with matching socket (CON2)
1 3-way vertical pluggable terminal block with matching socket (CON3)
1 2-pin polarised header (CON4) (optional, for off-board clipping indicator LED)

Semiconductors

2 HN3A51F dual PNP low-noise transistors, SC-74 (Q1,Q3) (Digi-Key HN3A51F(TE85LF)CT-ND)
1 HN3C51F dual NPN low-noise transistors, SC-74 (Q2) (Digi-Key HN3C51F-GR(TE85LFCT-ND)
2 BC846C NPN transistors, SOT-23 (Q4,Q14) (Digi-Key BC846CMTFCT-ND)
1 FZT796A high-voltage PNP transistor, SOT-223 (Q5) (Digi-Key FZT796ACT-ND)
1 FZT696B high-voltage NPN transistor, SOT-223 (Q6) (Digi-Key FZT696BCT-ND)
1 MJE15030* NPN driver transistor, TO-220AB (Q7) (Digi-Key MJE15030GOS-ND)
1 MJE15031* PNP driver transistor, TO-220AB (Q8) (Digi-Key MJE15031GOS-ND)
1 BD139* NPN transistor, TO-225AA (Q9) (Digi-Key BD139GOS-ND)
2 NJL3281D* NPN ThermalTrak transistors, TO264-5 (Q10, Q11)
2 NJL1302D* PNP ThermalTrak transistors, TO264-5 (Q12, Q13)
1 BC856C NPN transistor, SOT-23 (Q15) (Digi-Key BC856CMTFCT-ND)
1 FJV1845E 120V 50mA NPN transistor, SOT-23 (Q16) (Digi-Key FJV1845EMTFCT-ND)
1 wide viewing angle blue LED, SMD 3216/1206 (LED1) (Digi-Key 754-1439-1-ND)
2 red/green dual SMD LEDs, 3226/1210 (LED2,LED3) (Digi-Key 350-2081-1-ND)
1 yellow high brightness LED, SMD 3216/1206 (LED4) (Digi-Key 350-2050-1-ND)
4 BAV99 high-speed series double diodes, SOT-23 (D1,D5-D7) (Digi-Key 568-1624-1-ND)
1 MMBD1401A high-voltage diode, SOT-23 (D2) (Digi-Key MMBD1401ACT-ND)
2 VS-3EJH02 hyperfast soft recovery 3A diodes, DO221-AC (D2,D4) (Digi-Key VS-3EJH02-M3/6BGICT-ND)
2 4.7V Zener diodes, SOT-23 (ZD1,ZD2) (Digi-Key BZX84B4V7-FDICT-ND)
* Use On Semiconductor branded genuine parts

Capacitors (SMD 3216/1206 or 2012/0805 ceramic unless specified)

1 1000μF 6.3V SMD electrolytic, 8mm diameter (Digi-Key 493-6341-1-ND)
1 47μF 63V SMD (8mm) or through-hole electrolytic capacitor (eg, Digi-Key 493-6401-1-ND)
1 47μF 35V SMD electrolytic, 6mm diameter (Digi-Key 493-9433-1-ND)
1 47μF 16V non-polarised SMD electrolytic, 8mm diameter (Digi-Key 493-9818-1-ND)
2 47μF 6.3V X5R (Digi-Key 1276-1167-1-ND)
7 1μF 100V X7R (Digi-Key 1276-2747-1-ND)
1 100nF 250V NP0/C0G ceramic capacitor, SMD 1812 or 2022 package (Digi-Key 445-15480-1-ND) OR
1 100nF 250VAC Polypropylene capacitor, 15mm lead spacing (EPCOS B32652A6104J) (Digi-Key 495-1333-ND)
2 1nF 100V NP0/C0G (Digi-Key 445-5759-1-ND)
2 150pF 200V NP0/C0G (Digi-Key 399-9174-1-ND)
1 15pF 100V NP0/C0G (Digi-Key 311-1838-1-ND)

Resistors (0.5W 1% Thin Film, 3216/1206)

3 12kΩ or 12.1kΩ (Digi-Key RNCP1206FTD12K1CT-ND)
2 6.2kΩ or 6.49kΩ (Digi-Key RNCP1206FTD6K49CT-ND)
4 2.2kΩ or 2.21kΩ (Digi-Key RNCP1206FTD2K21CT-ND)
1 510Ω or 511Ω (Digi-Key RNCP1206FTD511RCT-ND)
2 330Ω or 332Ω (Digi-Key RNCP1206FTD332RCT-ND)
1 220Ω or 221Ω (Digi-Key RNCP1206FTD221RCT-ND)
1 120Ω or 121Ω (Digi-Key RNCP1206FTD121RCT-ND)
3 100Ω (Digi-Key RNCP1206FTD100RCT-ND)
3 68Ω or 68.1Ω (Digi-Key RNCP1206FTD68R1CT-ND)
2 47Ω or 47.5Ω (Digi-Key RNCP1206FTD47R5CT-ND)
1 10Ω (Digi-Key RNCP1206FTD10R0CT-ND)

Resistors (other)

1 1MΩ 0.25W 1% 3216/1206 SMD
1 150kΩ 0.25W 1% 3216/1206 SMD
6 100kΩ 0.25W 1% 3216/1206 SMD
1 68kΩ 0.25W 1% 3216/1206 SMD
4 47kΩ 0.25W 1% 3216/1206 SMD
1 33kΩ 0.25W 1% 3216/1206 SMD
1 1kΩ 0.25W 1% 3216/1206 SMD
1 390Ω 1W 5% (Digi-Key RHM390BCCT-ND)
1 100Ω 1W 5% (Digi-Key A102496CT-ND)
2 68Ω 5W wirewound (for testing)
4 27Ω 1W 1% (Digi-Key 541-27.0AFCT-ND)
4 0.1Ω 3W 1% Metal Film/Element (Digi-Key CRA2512-FZ-R100ELF)

higher rail voltage differential.

This is not the simplest clip detector circuit but it presents an almost completely linear load to the amplifier output, to minimise the possibility of any distortion due to its input load current. It's connected to the driven end of L2, to give the amplifier the best chance to cancel out any non-linearities in the load it introduces.

Summary of improvements

The obvious changes to the circuit are the additions: the power indicator LED, fuse status LEDs, clipping indicator LEDs and clip detection circuitry, offset adjustment trimpot and output protection diodes. However, some of the changes compared to the Mk.3 version are more subtle.

First, the input RF filter capacitor has been reduced to 1nF to make the amplifier less sensitive to source impedance, as it was decided this is more than enough capacitance for good RF filtering. In addition, the input pair operating current has been reduced from 6.5mA to 2mA. This change was originally suggested by Alan Wilson for lowering noise although we were only able to measure an improvement of one decibel as a result. But the circuit also seems more stable with the new arrangement so it was a worthwhile change.

Two additional changes were made to improve stability in the front end, which have already been mentioned: the 1nF capacitor across Q4's collector resistor and the 15pF capacitor across the 2.2kΩ resistor in the two-pole compensation network. These changes and the improved layout have allowed us to reduce the value of the two main compensation capacitors from 180pF to 150pF while should improved distortion cancellation. It also worked reasonably well with 120pF capacitors but recovery from positive clipping was no longer clean so we went back to 150pF.

Since Q6 has a much higher gain than the BF469 used previously, we've had to increase Q4's collector resistor from 22kΩ to 150kΩ to limit currents to a safe level under fault conditions.

We've also increased the capacitance across the bias network (for the output stage) from 100nF to 47μF and also changed the front end negative rail RC filter from 10Ω/470uF to 100Ω/47uF to make clipping more symmetrical and provide slightly better fault tolerance.

Also, we found that the large bypass capacitors for the output stage are not necessary if the power supply leads are short and thick. Basically, their only benefit is to reduce the voltage drop in that wiring and thus maintain full power output at lower frequencies if that drop is significant. As such, they can be regarded as optional. The 1μF high-frequency bypass capacitors for each output transistor are sufficient to ensure stability and guarantee good performance.

You Must Use Good-Quality Transistors

To ensure published performance, be sure to use the low-noise transistors specified in the parts list. Be wary of counterfeit parts.

We recommend that all other transistors be from reputable manufacturers, such as NXP Semiconductors, On Semiconductor, ST Microelectronics and Toshiba. This applies particularly to the MJE15030 & MJE15031 output driver transistors.

Component selection

Even though the circuit retains considerable similarity to the Ultra-LD Mk.3, almost all the components besides the output and driver transistors have changed. This is mainly because, as we explained last month, we are using SMDs extensively in an attempt to keep signal paths as short as possible and provide a ground plane covering the entire front end. This also allows us to improve magnetic cancellation.

So we've had to be very careful to ensure that each new component provides equal or better performance to the through-hole part it replaces. The resistors and capacitors must have excellent linearity. For active components like transistors and diodes, we've chosen components with similar or better gain, bandwidth, lower parasitic capacitance, etc.

All the low-wattage resistors are thin-film types. Many SMD resistors have thick-film construction and have a worse performance than through-hole thin-film resistors; for an explanation, see www.davehilldesigns.com/smt_resistror_distortion_rev1.pdf [sic].

So you need to be careful to use the types we specify. The higher-power resistors in the circuit (1W and 3W) are thick film or bulk metal types but their values are low enough that the linearity is acceptable.

Some new components have been chosen for their physical size or configuration. For example, trimpot VR2 goes right in the middle of a critical part of the front-end circuit so we're using a tiny SMD type to make the layout in that section better. Having all components in the front-end being SMD types (besides CON1) allows a single unbroken analog ground plane under that section for maximum hum/EMI rejection.

Similarly, the SMD fuses and 0.1Ω emitter resistors mean that we can place them directly on opposite sizes of the PCB for maximum magnetic loop cancellation. With the through-hole parts in the Mk.3 amplifier, the side-by-side arrangement did not have as effective magnetic cancellation. And with the emitter resistors on the other side of the board, it should be easy to replace the fuses if necessary.

Capacitors

Many of the capacitors in this circuit must be almost perfectly linear to obtain the desired performance. We extensively tested C0G/NP0 ceramic "chip" capacitors in comparison to polypropylene types, which are generally regarded as among the best available. There was no measurable difference. Many of the C0G/NP0 capacitors need to be rated at 100V or 200V as they may be exposed to voltage swings close to the full rail-to-rail supply voltage.

Note that "C0G" and "NP0" mean the same thing. They refer to a type of low-K ceramic dielectric which has an effectively zero temperature coefficient.

For bypassing, multi-layer SMD ceramics with X5R or X7R dielectrics are used. These have extremely low ESR and work very well in this role. Where larger-value bypass capacitors were called for than are practical for ceramic types, we used SMD electrolytics to ensure the ground plane "shield" is unbroken.

Our attempts to use X5R/X7R ceramic capacitors for signal coupling failed miserably so we went back to a non-polarised electrolytic type; plastic film types are too bulky and tantalums too unreliable. The problem is that all multi-layer ceramic capacitors, with

. . . continued on page 112

Low-cost, Accurate Voltage/Current/ Resistance Reference

This small module is based on a lithium coin cell, a voltage reference IC, a precision resistor and little else. It provides a reference voltage of 2.5V±1mV (±0.04%), a resistance of 1kΩ±1Ω (±0.1%) and a current of 2.5mA±3.5μA (±0.14%). It can be used for checking or calibrating multimeters or anywhere that an accurate and stable voltage is required.

How accurate are your multimeters? This accurate Voltage/Current/Resistance Reference is ideal for checking and calibrating multimeters on a regular basis.

By Nicholas Vinen

THIS SMALL module can be kept with your multimeter or other test instrument and used to periodically check its calibration. With occasional use, the battery will last for its shelf life which is normally at least 10 years for a fresh cell.

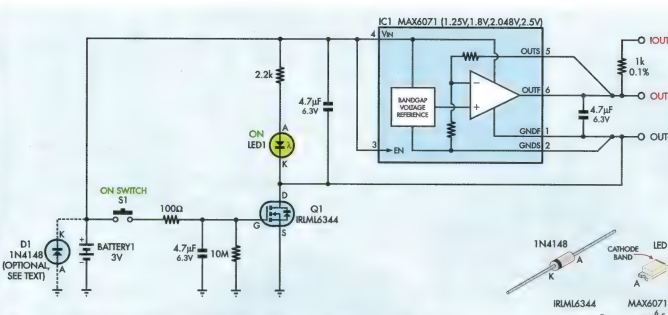
It can sink or source up to 10mA so the accuracy of the reference voltage is not affected by bias currents and a divider can be connected across the outputs to provide lower reference voltages, as long as its impedance is at least 250Ω. For example, this would allow it to be used in combination with our Lab-standard 16-Bit Digital Potentiometer from the July 2010 issue to give an adjustable reference voltage from 0V to 2.5V in 38μV steps.

It could also be hooked up to a microcontroller to be used as an analog-to-digital converter (ADC) reference voltage, for accurate voltage measurements by the micro.

This project effectively supersedes the Precision 10V Reference published in the March 2014 issue (and the one from May 2009 too). While this one is not adjustable and its output voltage is lower, its basic accuracy is better, it's much smaller and cheaper to build, uses a much smaller (and cheaper) battery and the previous projects did not offer the resistance or current references.

Circuit description

The full circuit is shown in Fig.1 and there isn't much to it. IC1 is the Maxim voltage refer-



SC VOLTAGE/CURRENT/RESISTANCE REFERENCE 3V VERSION

Fig.1: the circuit is based on a MAX6071 2.5V precision voltage regulator. Mosfet Q1 switches power to the circuit for 15-20s when ever pushbutton switch S1 is pressed.

ence which contains a band-gap circuit and precision op amp with trimmed resistive divider. The band-gap circuit measures the voltage across a couple of PN junctions and incorporates temperature compensation so that its output is stable (typically just 1.5ppm change per degree Celsius).

The band-gap reference produces 1.25V and the internal op amp and resistors provide a suitable gain to give the specified output. In this case, we're using a 2.5V reference, although other values are available and can be substituted.

We're using 4.7µF input bypassing and output filtering capacitors for a stable output voltage. LED1 and its series current-limiting resistor are connected across the reference's supply so that the LED lights while ever the reference is powered.

Mosfet Q1, together with pushbutton S1 and the RC network, switches power to the reference for a limited time, so that the cell won't be accidentally discharged.

When S1 is pressed, a third 4.7µF capacitor charges from the 3V battery supply via a 100Ω current-limiting resistor. This capacitor is connected between Q1's gate and source terminals so when it charges up, Q1 switches on and connects the reference ground to battery ground, thus switching it on.

A 10MΩ resistor across this 4.7µF capacitor discharges it over the course of about 15-20 seconds and once its voltage drops low enough, Q1 switches off and current flow from the battery ceases. Thus, S1 is pressed before the reference is used and provides power for long enough for a measurement to be taken. Total current draw is around 0.6mA when the reference is powered (150µA for IC1 and 450µA for LED1) and Q1's leakage current when off is less than 1µA.

The output reference voltage is available between the OUT+ and OUT– pads on the PCB. A 0.1% 1kΩ precision resistor is connected between OUT+ and IOUT and so resistance calibration can be performed between these two terminals. Together, the voltage reference and precision resistor provide an accurate 2.5mA current between the IOUT and OUT– terminals. The separate calibration article in this issue describes how measurement shunt resistance can affect this current.

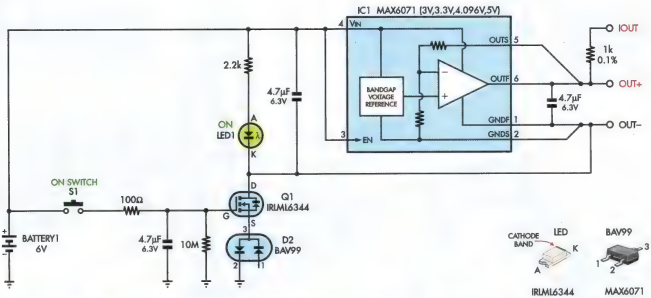
Note that if all you want is a voltage reference, you can leave the 0.1% resistor out of circuit.

Some button cell holders (including the type Jaycar stocks) will not apply power to the circuit if the cell is inserted upside-down. However, some do but we can't use a series diode for reverse polarity protection as we normally would, since IC1 requires a minimum of 2.8V to operate and even a Schottky diode would reduce the 3V from the cell by too much.

Thus, an optional 1N4148 diode (D1) can be reverse-connected across the holder to provide protection in case the cell is accidentally inserted backwards. The internal resistance for a

Features & Specifications: 2.5V Version

Reference voltage: 2.5V±1mV, 0-10mA sink/source
Reference current: 2.5mA±1.4µA, 1kΩ source impedance
Reference resistance: 1kΩ±1Ω, 1/8W
Power supply: 3V lithium button cell
Operating current: ~600µA
Standby current: <1µA
Cell life: typically >10 years with intermittent use
Other features: auto-off (20s), power indicator LED, compact size



SC 02015 VOLTAGE/CURRENT/RESISTANCE REFERENCE 6V VERSION

Parts List

1 double-sided PCB, code 04108151, 44.5 x 23mm
1 tactile pushbutton with short actuator (Jaycar SP0600, Altronics S1120)
1 50mm length 20mm-diameter clear heatshrink tubing

Semiconductors
1 IRLML6344 N-channel Mosfet, SOT-23 package (Q1)
1 1N4148 small signal diode (D1)

Capacitors (SMD 3216 [1206] or 2012 [0805])
3 4.7µF 6.3V X5R/X7R ceramic

Resistors (1% SMD 3216 [1206] or 2012 [0805])
1 10MΩ
1 2.2kΩ
1 1kΩ 0.1% 2012/0805 (eg, element14 1506077)
1 100Ω

Additional parts for versions up to 2.5V output
1 20mm button cell holder (Jaycar PH9238, Altronics S5056)
1 CR2032 3V lithium cell
1 MAX6071AAUT25+T 2.5V reference IC* (IC1)
1 high-brightness red, green or yellow LED, SMD 3216 (1206) or 2012 (0805) package (LED1) (eg, element14 2290347)
1 1N4148 small signal diode (D1)

*** OR**
1 MAX6071AAUT12+T for 1.25V output
1 MAX6071AAUT18+T for 1.8V output
1 MAX6071AAUT21+T for 2.048V output

Additional parts for versions over 2.5V output
1 dual 20mm button cell holder (element14 3029827) plus 2 x CR2032 3V lithium cells

OR
1 20mm button cell holder (Jaycar PH9238, Altronics S5056) plus 2 x CR2016 3V lithium cells
1 MAX6071AAUT50+T 5V output reference IC** (IC1)
1 high-brightness blue LED, SMD 3216 (1206) or 2012 (0805) package (LED1) (eg, element14 2217982)
1 BAT54S or BAT54C dual SMD Schottky diode, SOT-23 package (D2)

**** OR**
1 MAX6071AAUT30+T for 3V output
1 MAX6071AAUT33+T for 3.3V output
1 MAX6071AAUT41+T for 4.096V output

Fig.2: this alternative circuit is used for output voltages of 3V or more. It's powered by a 2-cell (6V) battery and diode D2 is included to reduce the supply voltage to 5.5V.

CR2032 cell is typically 10Ω so if your holder does allow a cell to make contact upside-down, D1 should survive long enough for you to realise your mistake and protect IC1 from damage.

Different output voltages

IC1 can be changed to a 1.25V, 1.8V or 2.048V type with no other changes to the circuit. This is simply a matter of using an IC with a different part number (see the parts list).

We have chosen 2.5V as the "default" option since this is the highest reference voltage obtainable using a single lithium cell. However, 1.8V is also a good choice as many low-cost DMMs have a 2V range and thus this will be ideal for calibrating them. The 2.5V option works well for meters with a 4V range, which is quite common for more expensive multimeters.

You can also get an output of 3V, 3.3V, 4.096V or 5V but this will require a 2-cell battery to provide a sufficiently high input supply voltage. You have two options: either use a standard button cell holder and two slim cells (CR2016, ~100mAh) or use a double-stack cell holder and two of the more common CR2032 cells (~200mAh).

There are two advantages to using

CR2016: (1) you can get the holder and cells from a local store (eg, Jaycar) and (2) the resulting unit is a little more compact. Unless you will be using the unit frequently, the reduced cell capacity probably won't matter.

Regardless, when using two cells, diode D2 will need to be fitted. That's because IC1's maximum recommended operating voltage is 5.5V and D2's forward voltage will reduce the ~6V from two fresh cells to be very close to 5.5V. The alternative circuit is shown in Fig.2. With D2 in circuit, there's no need to fit D1 as D2 will block reverse current. Otherwise, the circuit remains the same.

Construction

Most of the parts are SMDs and all but one have widely-spaced connections, making them easy to solder. The only slightly tricky one is IC1 but it really isn't that hard. It's best to solder the SMDs first, starting with IC1, before finishing with the through-hole parts. Refer to the appropriate overlay diagram – Fig.3 for outputs of up to 2.5V and Fig.4 for higher voltages.

First, it's a good idea to clean the PCB by swabbing it with a little alcohol (eg, methylated spirits) and a lint-free cloth. Also, applying flux to the SMD pads before soldering will make the job easier.

Melt a little solder onto one of IC1's six pads, then place the IC alongside and inspect it under magnification. There will be a small dot laser etched on top. This is the pin 1 marker and it goes towards the dot in the lower-right corner of the PCB. Orientate IC1 as such, then heat the solder you added earlier and slide the chip into place using angled tweezers.

If it appears that IC1 is correctly placed, gently press down on the chip using the tip of the tweezers while heating the solder pad to ensure that it is sitting properly on the PCB. Then check under magnification that all six leads are centred over their pads.

Once it's in place, solder the leads on the opposite side (don't worry about bridging them), then go back and solder the three on the other side, including the one you tacked down earlier. Add some more flux, then clean up the joints using some solder wick. This will remove any bridges and should also ensure that a proper fillet has formed for each pin. Remove any flux residue using alcohol or a proper flux solvent and then inspect with magnification to ensure all leads have been soldered properly.

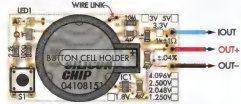


Fig.3: follow this PCB parts layout diagram to build the versions with outputs up to 2.5V.

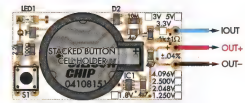
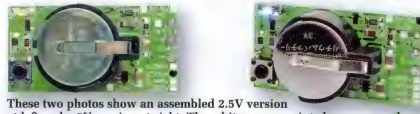


Fig.4: this is the layout for the 3V to 5V versions. It includes diode D2 and a 2-cell holder.



These two photos show an assembled 2.5V version at left and a 5V version at right. The white screen-printed squares on the PCB let you mark the selected output voltage. It's a good idea to cover the completed assembly in clear heatshrink tubing.

Diode D1 in the 3V-powered version is optional. It can either be soldered across the battery holder on the underside of the PCB as shown at left (anode to positive) or it can be left out as shown at right (see text).

You can then move on to Q1 and, if you are building the 6V-powered version, diode D2. These are easier to solder as their leads are much further apart. As before, tack one lead down first, then check that the device is flat against the PCB and that its leads are properly lined up with the pads before soldering the remaining pins and refreshing the first one.

Be careful when fitting D2 as two of the pads are quite close together and easy to accidentally bridge. If you are not fitting D2 then these two pads should be shorted, either with a solder bridge or a very short length of wire (eg, made from a component lead off-cut).

You can now fit the resistors and capacitors in a similar manner, as shown in Fig.3 or Fig.4. The resistors will have their values marked on top (eg, 1001 = 1kΩ, 222 = 2.2kΩ), while the capacitors will be unmarked.

The last SMD is LED1 but you will have to check its orientation first. Set a DMM to diode test mode and connect the probes to either end. If it lights up, the red probe will be on the anode and this goes in the corner of the board. Try to avoid heating it up too much as this can damage the LED. If it doesn't light up in either orientation, your DMM may not put out enough voltage in which case you'll have to use a small battery with a current-limiting resistor to determine the anode.

Once LED1 has been fitted, solder the tactile pushbutton and cell holder in place. In both cases, push them down hard to make sure they are flat on the PCB before soldering their pins. The cell holder will have three plastic posts which go through matching holes in the board. You may have to push fairly hard to get these to go in.

Optional diode D1

Finally, if building the 3V-powered version, you can flip the board over and solder the 1N4148 diode in place as shown on the above photo. Alternative, you can leave this out if you're confident that you will always install the cell with the correct polarity. We're

Using This Board With An Arduino

If you're going to use this board with an Arduino, you can omit some of the parts. You certainly won't need the cell holder or pushbutton switch as power will come from the Arduino board itself. You could also leave off Mosfet Q1 and short it out if you don't need the micro to be able to switch the reference voltage on and off.

For now though, we're assuming this is useful, so Fig.5 shows how you can wire it up. The reference IC runs off 5V from the Arduino, which means you can't use the 5V reference but any of the others should be OK. The "enable" line can be driven from one of the micro's outputs to turn the reference voltage on and off if required, or tied to the 5V rail to leave it permanently on.

Note the top layer track cut. This is important for maximum accuracy because without it, some of the supply current for the reference could flow via the analog ground connection and cause a voltage drop across it, which would reduce the voltage seen by the micro's AREF pin.

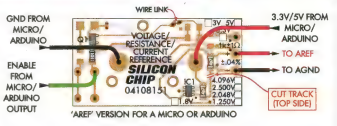


Fig.5: here's how to interface the unit to an Arduino for accurate ADC measurements. Note that you need to cut one of the PCB tracks.

When writing software for the micro, keep in mind that you will probably need to tell the ADC to use the AREF input as its voltage reference, rather than its AVDD supply rail voltage. Its full scale reading (eg, 1023 for a 10-bit ADC) will then indicate a voltage equal to (or just slightly less than) the new reference voltage, rather than the 5V reading it would have indicated previously. This means that you may need to re-scale the results to suit the new ADC reference voltage.

Note that, if using the enable feature, the AREF pin will be pulled near the positive supply input when the reference is disabled. If the micro is running off 3.3V, it's likely it will not tolerate 5V on this pin, so be sure to either run the reference off the 3.3V supply or leave it permanently enabled.

not sure whether IC1 would survive a reversed cell; it might, due to the cell's internal resistance limiting current but we haven't been game to test this.

Finishing it up

Before placing the unit in its protective heatshrink sleeve, check that it's working properly. First you need to insert the cell (or cells). Check the polarity markers on the holder and cell(s) and then slide them into place.

Next, press S1 and verify that LED1 lights up, then goes out about 20s later. Note that if you touch the back of S1, your skin resistance can be enough to cause the unit to turn on briefly (this will be prevented once the heatshrink is in place). If LED1 does not turn on, it may have been fitted backwards or there could be a soldering problem. Press S1 and measure the voltage across LED1; if it is 2V or more, then LED1 is suspect, otherwise voltage is not getting to it for some reason.

Assuming LED1 lights up, measure the voltage between OUT+ and OUT– and verify that it's within specifications. If it seems low, press S1 again to ensure Q1 is fully on. Now is also a good time to use a marker pen to indicate which output voltage has been selected by marking one of the rectangles provided on the PCB silkscreen.

If you've fitted the 1kΩ resistor you can now check its resistance (between OUT+ and IOUT) and verify the expected current by connecting a DMM set to measure milliamps between IOUT and OUT-. Note that the reading may be a little lower than expected; see the article on multimeter calibration in this issue for an explanation.

Now it's just a matter of sliding the clear heatshrink tubing over the unit and shrinking it down. Don't cover the test terminals right at the end of the board, although it's a good idea to insulate everything else. You can cut off any excess after shrinking. Note that if using the double-stack CR2032 cell holder, the tubing will be a tight fit but we managed to get it onto our prototype unit OK.

You're now ready to check and/or calibrate your multimeter(s) – see the accompanying article for details on doing this.

Other uses

This voltage reference may also be useful to allow very accurate voltage measurements to be made by microcontrollers, including those on Arduino boards.

The ADC in a microcontroller needs some sort of reference voltage. This is usually either its supply voltage (5V or 3.3V) or an internally generated reference. However, the internal reference is usually pretty inaccurate (±0.1V is typical) so in most cases you're better off using the supply voltage instead. This also has the advantage that any voltage up to the supply voltage can be measured using the ADC.

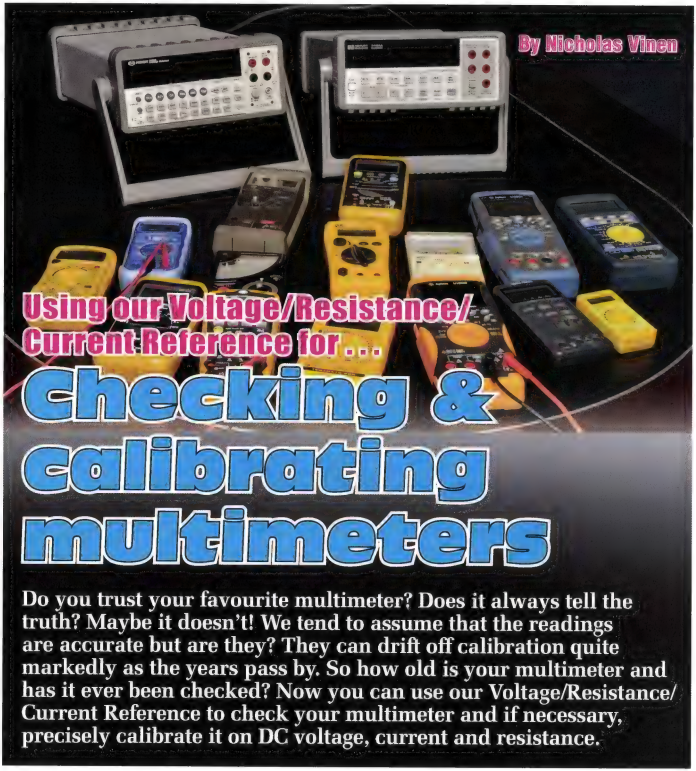
However, you are then at the mercy of the accuracy of the regulator providing this supply. It may have a stated error of less than 1%; for example, the MCP1700 low-dropout linear voltage regulator has a typical tolerance of ±0.4%. However it isn't uncommon for a linear regulator to have a much larger output voltage error such as ±2% or even ±5%.

You also have to consider noise which may be injected into this rail from other devices drawing power in bursts, which can add an extra layer of uncertainty to ADC measurements.

It's much better to use an accurate voltage reference, normally fed into a dedicated pin on the micro (labelled something like "AREF"). This will be free of noise and has the potential to have a much better defined voltage.

Note though that if you expect to make accurate measurements using an ADC fed with such a reference voltage, you will also need to make sure that any voltage dividers feeding ADC inputs use resistors with accurate values or that you have the ability to trim them. You will also need to keep the source impedance for the ADC inputs low, ie, don't use high values in the divider.

If in doubt, check the microcontroller's data-sheet. SC



By Nicholas Vinen

Using our Voltage/Resistance/Current Reference for . . .

Checking & calibrating multimeters

Do you trust your favourite multimeter? Does it always tell the truth? Maybe it doesn't! We tend to assume that the readings are accurate but are they? They can drift off calibration quite markedly as the years pass by. So how old is your multimeter and has it ever been checked? Now you can use our Voltage/Resistance/Current Reference to check your multimeter and if necessary, precisely calibrate it on DC voltage, current and resistance.

DEPENDING ON how much you paid for you multimeter, it may have been very accurate when new. But if it's a few years old, its readings might now be far from accurate. How would you know? You need to check it regularly against a reference to ensure it still meets its specifications.

Ideally, you need several references; at least one voltage reference, one resistance reference and one current reference. Luckily, our Voltage/Resistance/Current Reference described elsewhere in this issue gives you all three, without you having to spend much money.

Of course, professional multimeter calibration operations need to have more complex equipment than this; they will have very accurate references that are themselves periodically checked against even more accurate devices and which can be adjusted to give voltages/currents/resistances/etc that allow each range of a multimeter to be calibrated accurately. While our project only supplies a fraction of that, it's still a lot better than nothing.

So assuming you've built our Reference module, how do you go about

If you don't have a service manual for your multimeter, you will have to figure out which pot does what by a process of trial and error.

checking and calibrating your multimeter?

Checking voltage accuracy

First, if you have a very accurate multimeter that itself has been recently calibrated in a NATA-approved facility, you can use it to test your reference device and write down the measurements. If you don't have such a meter, you will simply have to assume that the Reference is perfectly accurate. If using our reference device, this is not a bad assumption – we measured the nominal 2.5V output error (on a 7.5-digit multimeter) as just -0.0005% (see photo overleaf)! Similarly, the nominal 1kΩ resistor was just 0.0134% low (compared to a 0.1% specification).

Now set the multimeter to be calibrated into DC voltage measurement mode and set the range to the lowest range that will read the test voltage (if it's auto-ranging, it will select this automatically). Connect the probes to the OUT+ and OUT– terminals on the reference, switch it on and check the reading. If it is as close to the expected value as the meter can read, you know it's properly calibrated. You can reverse the probes and check that the negative reading is equally accurate.

You can also check that the reading is correct on higher settings, although the number of digits shown will of course be reduced so this will be a less accurate test. Still, it's worth doing. Note that a typical DMM typically only has a single adjustment for its DC voltage mode so if it is out in some ranges and not others, you probably won't be able to improve the situation without actually replacing some of its on-board multiplier resistors.

For checking lower voltage ranges, where the output of the reference will give an over-range error, you could connect a resistive divider or potentiometer across the reference outputs, measure the resulting voltage on the higher range and then check that the lower range gives a similar reading.

Resistance mode

Checking the resistance reading is a similar process. Set the DMM on its lowest mode that can read 1kΩ (this will usually be the 2kΩ, 4kΩ or 5kΩ range) and check that the reading is as close as possible to the actual value.

To check higher ranges, you could use the same resistor however it's better to pick a "random" resistor which is just below the maximum you can read on the current range, note its value, then switch to the next higher range and verify that the reading is very close. You can then pick a resistor with 10x the value as the last and repeat the process up through the ranges.

Ranges below 1kΩ can be checked using the same procedure, ie, pick a resistor with a value that's towards the upper limit of the lower range (eg, 180Ω), read this value on the same range as you used to check the 1kΩ calibration resistor, then switch into the lower range and verify that the reading is correct. Then using a smaller value again, proceed down through the lower ranges.

Of course, the ideal situation would be to have a precision resistance box or a series of individual precision resistors but in practice, this cheaper method should do the job.

Ammeter checking

Testing an ammeter with the current source on our reference board is a little more involved because it has a high output impedance of 1kΩ. That means that, depending on the multimeter's range setting, its shunt resistance (and by implication, burden voltage) will affect the reading. However, you can easily compensate for this. The simplest method is to use a second multimeter to measure the shunt resistance of the meter being tested. The current is nominally 2.5mA for the 2.5V unit (5mA for the 5V unit, etc) so it should be suitable for testing both milliamp and microamp ranges (if present). To measure the shunt resistance, set the DMM on the range being tested, then connect the second meter in resistance mode between its current measurement terminals.

On our example meter, we got a reading of 101.28Ω on the microamps range, 2.2Ω on the milliamps range and 0.077Ω on the amps range.

You can then calculate what the meter should read in each range by adding the calibration resistor value to the measured shunt resistor values and dividing into the reference voltage. In our case, our calibration resistor measured 999.866Ω (an error of just -0.013%!) and our reference voltage

While the nominal accuracy of the Maxim voltage reference is ±0.04%, typically it will be much better, as demonstrated by this readout on the Keysight 34470A bench multimeter reviewed in this issue.

2.499987V. Thus the expected readings for this meter are:

(a) 2.499987V ÷ (999.866Ω + 101.28Ω) = 2.270mA in µA mode

(b) 2.499987V ÷ (999.866Ω + 2.2Ω) = 2.4948mA in mA mode

(c) 2.499987V ÷ (999.866Ω + 0.077Ω) = 2.5mA in A mode

We didn't calibrate the example DMM but we did check its readings against these and got 2.270mA, 2.495mA and 2.5mA respectively. So it seems it doesn't need any adjustments for now.

Performing calibration

If any of your checks give results with a noticeable deviation from the expected values (ie, more than ±1), you will probably want to trim the meter to make it more accurate. Unfortunately, the procedure for doing this will be different for each meter but there are some common steps.

First, you need to gain access to the trimpots on the PCB(s). This usually involves removing the back of the meter. If it is in a rubber holder, remove that first, then look for screws on the back. There are usually 2-4 screws holding the back on. You may also need to remove the battery cover first.

Usually, having undone the screws, the back will pull off quite easily. Modern DMMs are usually built on a single board but some may comprise two PCBs joined with headers or some other form of connector. Inspect the board(s) and locate any trimpots. We've seen as few as one and as many as 12!

If you're lucky, a service manual will be available on the internet for the model of multimeter you are calibrating which details the location and function of each trimpot.

For example, we had a look for the manual for our venerable Fluke 77 and found it at the Fluke website. It confirms that the single trimpot is used to adjust the DC voltage reading. They suggest using a test voltage of 3V, which our reference board can provide with a suitable reference IC, however 2.5V should work fine too.

There should be a manufacturer-provided service manual available for just about every modern, brand-name DMM on the market. If you have a re-badged DMM, you may have some luck if you do a web search to find out the original manufacturer's model number for that product, then look up the service manual for that product.

If you can't find a manual for your meter but there's only a single pot, chances are that, like the Fluke 77, it adjusts the reading in the DC voltage mode. In that case, it's just a matter of hooking the reference up and tweaking it until the reading is correct. It may or may not also affect the current and resistance readings.

If there are multiple trimpots though, it's unlikely they will be labelled with anything other than a code. If you can't find a service manual for your DMM, you'll have to figure out what they do the hard way.

First, take a photo of the trimpots so you can see which position each one is in, in case you can't easily re-calibrate it later. Then, switch the meter into each mode in turn and adjust each trimpot. You'll probably have to hook something up to the input terminals in each mode to make changes apparent. Once you figure out what a given trimpot adjusts, write it down and move onto the next mode.

Hopefully, by the end of this process you have a full list of what each trimpot does. You'll also likely have a meter that's way out of calibration! So calibrate the voltage, resistance and current pots using the previous explanations for how to check the operation of each mode. All you have to do is adjust the appropriate trimpot until each reading is correct (or as close as you can get it). If there are any pots that you can't calibrate, refer to the photo you took earlier to set them back into their original positions.

Note that in some cases, the pots themselves may not be directly accessible without removing the PCB or unplugging a sub-module, however you may find that you can adjust them from the back through holes in the board. Generally it's impossible to calibrate a multimeter without being able to observe the display while making adjustments so there's usually a way to do it with the board still in the case.

By the way, do not be tempted to use the 230VAC mains or other high-voltage sources to calibrate a DMM. It isn't safe to connect a DMM to the mains with the case open. You could get a lethal shock if you do.

Digital calibration

Some modern DMMs use digital calibration. There's no need to open the unit up; calibration is performed by manipulating the buttons on the front panel. For example, our Agilent U1252A and U1253B multimeters use this procedure.

In this case, you'll need the service manual for instructions on how to enter adjustment mode and perform the calibration. It's usually a similar process to adjusting trimpots, except that the up/down adjustments are made using pushbuttons instead. You'll still need the reference board to make the adjustments. SC

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Stranded by a Flat Battery near Woop-Woop? Never Again!

by Ross Tester

It's an all-too familiar scenario. You're out the back of Woop-Woop* and have had a great day . . . until you return to your car and find you've left the lights on. You turn the key (or more likely press the engine start button) and the starter motor clicks but that's about all.

What to do? You could phone a friend (is there mobile phone service at Woop Woop?) but you could be in for a long wait. Similarly, you could call Road Service – ditto the wait. Or you could wait until someone else comes along AND has a pair of jumper leads.

Oh yeah?

Or you could . . .

Or you could open the car boot, take out a small package, connect its leads to your car battery . . . and start your car. That's if you happened to have one of these "Battery Fighters" from Master Instruments.

They come in various models, to suit all sizes of vehicles from small motorcycles to large cars and SUVs. There's even a 24V model to suit trucks and heavy vehicles with the higher voltage system.

The Battery Fighters are portable, lithium-polymer powered devices which offer starting "grunt" far greater than their size would suggest is available. For instance, the smallest 1500mAh model (which fits in the palm of your hand) offers 150A cranking – suiting engines up to about 1200cc.

The significantly larger (though still reasonable sized) truck models are rated at 12V or 24V, 9000mAh but can handle notoriously more demanding diesel engines (as well as petrol) up to 13 litre capacity in the case of the 24V JPR9024M, with their 810A cranking availability.

This one weighs 2.2kg, reflecting the size of the cells it contains.

All models are said to be good for ten cranks, so if the engine doesn't start first off, you should still be able to get it to go.

If you're in any doubt as to whether the particular Battery Fighter model has the power to handle your particular vehicle, there's a handy chart printed on some models to tell you.

Simply choose the model suitable and you can be assured you're ready for the deep unknown . . .

But wait, there's more!

On most of the models, there is also a 5V USB output which can be used to charge and/or power your mobile phone and other 5V devices. Again, when you're stuck in the scrub without power this could be a lifesaver! The USB outlet is rated at 2A so is more than capable of supplying the power you need.

Obviously, it's capable of supplying power to much more than mobile phones. Given the number of "5V" or "USB" devices around these days, you almost certainly have several in your arsenal which could benefit from having reliable (and virtually unlimited, with reason) power available.

We don't believe USB cables are supplied with any of the Battery Fighters, mainly due to the number of different USB connectors used (then, of course, everybody has a spare cable or two!).

Work light

Given the fact that the most usual

*** Woop Woop: that mythical place you're out the back of, when something goes radically wrong.**

This one is the 12V/4500mAh JPR4500M, which is good for all engines up to about four litres and has a suggested price of $239.95. There are five models in the series, ranging from the 1500mAh JPS1500M @ 149.95 through to the "big daddy" , the 24V 9000mAh Truck starter (good for 810A) which retails for $799.95. All contain lithium-polymer batteries and come with the range of leads, charger and case shown here.

application for the Battery Fighter will be in the pitch black when there's no battery to power a work light (Murphy's Law No XIV), they've thoughtfully included a high power LED work light (and in some cases two!) in each model. Very handy when you are out the back of Woop Woop!

In use

It's simply a matter of connecting the large alligator clips to your battery, as you would a set of jumper leads. The output is short circuit proof so you won't get that nasty "splat" when the leads short together!

A range of indicators on the side of the units tell you what status your battery is in (as if you didn't know – it won't start!). In addition, the information is repeated in the quite comprehensive intruction manual.

You press the "JUMP START" button and it's ready for you to crank the engine in the normal way. Once it's started, you turn off the power and disconnect the Battery Fighter. Unlike jumper leads, there is no risk of spark and/or explosion.

If the engine dies once the Battery Fighter is turned off, it's a pretty safe bet that your alternator and/or electrical system is faulty. We are given to understand that the Battery Fighter cannot be used to drive, or even limp home, because it will turn itself off after two minutes. It automatically limits individual cranking times to three seconds.

OBD II "Saver" function.

What impressed us – apart from the units themselves – was the extensive range of leads and adaptors supplied with each one. These vary according to the size of the unit but all include heavy-duty 100% copper jumper cables.

All except the 24V Truck model include USB output cables; some also sport an OBD II connector plug, which is used to "power up" the car, maintaining alarm and radio codes and other computer information while the car battery itself is changed. While modern cars are usually capable of holding this information for a short time, if left too long (ie, when a battery is dead flat or removed) it can be lost – and on some cars, this is a disaster!

The OBD II cable simply plugs into the normal Battery Fighter output socket and into the OBD II socket, normally located under the dashboard.

After use

The Battery Fighter is supplied with a 12V 1A switch-mode plugpack, which is used to charge the lithium-polymer cells. It is recommended that the unit is checked every three months to ensure the cells are charged and ready for use.

Where from?

The Battery Fighters all came from Master Instruments, with offices in Sydney, Melbourne Brisbane and Perth. Full contact details and technical specifications are at **www.battery-fighter.com.au** SC

Review by Nicholas Vinen

Keysight 34470A 7.5-digit bench multimeter review

This 7.5-digit benchtop multimeter supersedes the venerable 34401A which dates from the Hewlett-Packard era. In addition to its high measurement precision, it has wide measurement ranges, a 4.3-inch colour LCD, standard USB and ethernet ports, high-speed data logging modes, histogram/chart plotting modes and more.

AS YOU WOULD expect for a 7.5-digit multimeter, the 34470A has impressive accuracy specifications; its basic DC voltage accuracy is specified as 16 ppm or an error of just 0.0016%. We won't list all the accuracy figures here as they would take too much space. If you're interested you can look up the specification sheet at www.keysight.com/de/pd-2520154-pn-34470A/digital-multimeter-7-digit-performance-truevolt-dmm

The 34401A is a Cat.II unit with the following modes: DC and AC volts, DC and AC current, 2/4-wire resistance, frequency, capacitance, diode test, continuity and temperature. The resolution at its most sensitive settings is 1µV (DC/AC volts), 1nA (DC/AC amps), 0.1mΩ (resistance), 0.01mHz (frequency), 0.1pF (capacitance), 0.1mV (continuity), 0.001° (temperature).

Maximum readings are 1000/700V (DC/AC volts), 10A (DC/AC amps), 1GΩ (resistance), 300kHz (frequency), 100µF (capacitance) and 5V (diode test). For the temperature mode, RTD, PTC, thermistor and thermocouple probes are supported. It has front and rear panel inputs and the active inputs are switched by a latching pushbutton.

As with most high-precision multimeters, there is an accuracy/speed trade-off. This unit is capable of up to 50,000 measurements per second when it's used in a data-logging or PC-connected mode but when operated at that rate, it only reads four digits. To get the full 7.5 digits of precision, it needs to average its readings over 10 power line cycles, so with our 50Hz mains that means five readings per second. Of course, that's more than adequate when you're using it as a DMM.

In fact, in any mode, you can select the sampling rate as either a multiple of power line cycles or in milliseconds and the unit will then adjust the number of digits displayed to reflect how accurate the readings are under that condition.

You also get the choice to override the number of digits displayed; eg, to eliminate last digit "bobble" when you simply don't need that much precision. Having said that, in 7.5-digit mode, the last digit is usually pretty

stable with only a little noise evident.

This unit features Keysight's "TrueVolt" technology which uses high-speed digital sampling to compute true RMS values. This allows for accurate measurements with a crest factor of up to 10, compared with a typical figure of only three for devices which do the RMS conversion in the analog domain. They also claim significantly lower input bias current (25pA) and noise (~50nA) than their competitors, for accurate readings on the lowest ranges.

For voltage readings on the 100mV, 1V and 10V ranges, the input impedance can be increased from 10MΩ to 10GΩ which will result in much more accurate readings when the source impedance is high. Also, when sensing small currents, it will withstand up to 3A; some multimeters limit you to 1A or 500mA under such conditions and it's easy to accidentally blow the fuse.

Advanced features

That's all pretty standard, albeit impressive stuff. What we're more interested in though are the extra features that they've built into the unit, along with some simple niceties that make your life easier when using it.

As an example of the latter, in most modes the default is for the single reading to dominate the display (see lead photo). But you can also select a second reading to be displayed in a smaller font below the main reading (the main reading will shrink slightly; see Fig.1). For example, in DC volts mode, the second reading can either be AC volts (ie, ripple), minimum/maximum/peak-to-peak readings or the "pre-math" reading (eg, if you have nulled out an offset, this reading includes the offset). Other modes offer similar options.

The Display menu allows you to enable a bargraph display which appears below the numeric reading(s) in any mode (see Fig.2). This is very convenient for quickly being able to see how a value is changing over time and its response time is pretty fast; up to 10 updates per second.

You can also enable a statistics display which shows the number of samples collected, minimum, average, maximum, span (ie, peak-to-peak) and standard deviation. In fact, the display is large enough that you can enable the second reading, bargraph and statistics all at the same time and they are all legible as long as you aren't too far away from the unit.

Or you can move the measurement into the top lefthand corner of the screen and the centre is then dominated by a trend chart (Fig.3) or histogram (Fig.4). The trend chart mode is like having an oscilloscope with a very long timebase, although unlike a scope, the readings can be AC voltage, current, resistance etc.

The timebase can be set to give a full-screen span of 1, 5, 10, 30 or 60 minutes. You can also temporarily switch to a display which shows all readings taken so far. The vertical scale can be set manually or automatically determined, based on the range of readings so far.

Data is shared between trend and histogram mode, so you can switch back and forth between them without losing data. And in histogram mode you can either have automatic or manual binning (ie, the extents of the horizontal axis). There are also options for cumulative mode and for cursors.

Importantly, you can save the captured data at any point, either into internal storage or to a USB flash drive plugged into the front panel.

Additional modes

Then there are the "math" modes which include measurement scaling. These allow readings to be shown in dB, dBm, % or Mx-B with adjustable reference values. There's also the usual nulling offset adjustment plus the option for a smoothing filter with a response time of 10, 50 or 100 readings.

One very simple but clever feature that we think will really come in handy is "probe hold". This can be activated in any mode and it waits for the reading to become stable, then stores it in a list of up to eight readings. If you then probe a different part of the circuit and get a different reading, once

Fig.1: a voltage reading from our 2.5V reference project (presented elsewhere in this issue) in full 7.5-digit precision mode. A second reading, in this case AC voltage, is displayed below although this appears to be somewhat exaggerated as the noise voltage is so much less than the DC reading.

Fig.2: a mains voltage reading with frequency shown as the second measurement, along with the bargraph display. The bargraph makes it easy to see rapidly changing measurements.

it stabilises it too will be added to the list. This means you don't have to constantly swap back and forth between probing the circuit and making notes.

Unlike a handheld DMM, bench multimeters typically have various triggering options in addition to the normal "auto" triggering where sampling is continuous. This one supports external triggering as well as level-based (like a scope), single triggering (manual) or auto with a predetermined sampling rate. It can be configured to delay sampling from the trigger event and can also be set

The lower-cost model 34461A is a 6.5-digit version of the unit reviewed here. It has less memory and a slower update rate than the 34470A but has most of the latter's features. Refer to Keysight's website for further details.

The rear panel of Keysight's 34470A bench multimeter carries a wide range of input and output sockets. Note that the GPIB interface is an optional extra.

to produce multiple samples per trigger event.

Connectivity

The front panel USB port allows screen grabs, logged data or settings to be saved to a flash drive. Logged data is saved to a CSV (comma separated variable) file which can also include the date and time that logging started. Unfortunately, the mode and capture rate are not included so you need to note that separately if you want to plot the data as a time series.

The unit can also be controlled by a PC and data transferred using the rear panel USB socket or it can be done over an Ethernet network. Either way, it's done using the "BenchVue" software which is available as a free download for Windows, Android or iOS. Note though that some of the advanced features such as histograms and unrestricted data logging require the purchase of the "Pro" version.

The 34470A has a backwards compatibility mode which allows software written for the 34401A to work without (or with few) modifications. The 34401A was the standard instrument for so long that many contracts and specifications will be written with the 34401A in mind, so this is an important feature to give such users an upgrade path; especially since 34401A production will end in 2016, 24 years after its launch.

Fig.3: a trend plot of the AC mains voltage in our location over a 5-minute period. This shows ~30s variations in voltage which is not apparent looking at the waveform on a scope. It's probably due to some nearby industrial equipment cycling on and off.

Fig.4: a histogram of the same AC mains voltage data shown in Fig.3. The number of samples is shown along with the percentage represented by each "bin". The bins can be chosen automatically based on sampled values or else the number and span can be entered manually.

Minor issues

It's hard to fault the basic operation of this unit, ie, reading voltage, current and resistance. However, some of the other functions seem like a bit of an afterthought. For example, only being able to read signal frequencies up to 300kHz is rather limiting; many DMMs will go up to 10MHz or 20MHz. Similarly, the maximum capacitance reading of 100µF is a little low, although having said that, it will read very low values (<1pF) which is quite useful.

And while the diode test mode is great for checking LEDs, its 5V limit means it isn't much use for checking low-voltage zener diodes. A few DMMs have test voltages of around 20V which does allow this.

Of course, these are all relatively minor issues and will apply more or less equally to other bench multimeters.

By the way, we should point out that this unit takes a few seconds to "boot up" and calibrate; something that we're now pretty much used to with DSOs but not so with multimeters. And a further minor issue: when you go to save a screen grab or data series, the default name is always the same so you have to manually change it, rather than the software picking a new sequence number for you each time.

Options & accessories

Our review unit was supplied with some options installed. These include the capability of 50,000 readings per second (5000/s standard), two million readings memory (50,000 standard) and an optional GPIB interface.

While the review unit is a 7.5-digit type, three similar 6.5-digit models are also available: the 34460A, 34461A and 34465A. These differ in their basic accuracy, sampling rates, memory sizes, measurement ranges and capabilities. The 34465A is essentially identical to the 34470A except for being a 6.5-digit type with slightly worse accuracy figures, while the others lack some features (refer to the Keysight website for more details).

Conclusion

The 34470A is a worthy replacement for the 34401A. It brings greater accuracy and precision, a much better display and many useful new features. We particularly like its data logging and display modes, especially the fact that you can observe the data while capturing it and then off-load it to a PC for analysis without needing to connect the two directly.

The display and its flexible configuration are particularly nice to work with and the user interface is pretty easy to figure out. In essence, this type of unit brings the capabilities of the bench-top multimeter more in line with that of a modern DSO with screen-grab, data capture and display and convenient filtering and statistical analysis features.

The 34470A is available from Trio Test & Measurement (www.triotest.com.au) for $3420+GST. The 34465A is $1651+GST while the less-capable 34461A and 34460A are $1298+GST and $1118+GST respectively. For more information or to place an order, call Trio on 1300 853 407 or e-mail sales@triotest.com.au SC

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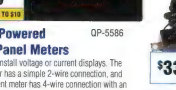

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DOUBLE POINTS

FROM **$5.95**

Tamper Switches

Pin style switches suitable for car doors or bonnets. Sold in pairs.

ECONOMY LE-8775 **$5.95**
HEAVY DUTY LE-8776 **$7.95**

LA-8904

DOUBLE POINTS

FROM **$9.95**

Waterproof Sirens

Suitable for most automotive applications. Produces loud 90dB sound. 12/24VDC.

REVERSE WARNING LA-8904 **$9.95**
MINI SIREN LA-8901 **$12.95**

LA-5327

DOUBLE POINTS

$**19.95**

Waterproof LED Strobe Lights

Ideal for security, alarm or emergency use. Mounts with 2 x 5mm bolts. 70(Dia) x 45(H)mm. 12VDC.

BLUE LA-5326
RED LA-5327
AMBER LA-5528

TOOLS THAT AUTO MECHANICS LOVE!

$9.95

Alternator/Battery Monitor PP-2142

Simply plugs into your car's cigarette lighter socket to check alternator and battery status. 12VDC.

$15.95

Cordless Voltage Tester QP-2212

Quick and easy way to locate electrical faults without a bulky meter. Works on 3-28V circuits. It lights up and buzzes when positive voltage is detected.

$59.95

Multi-Function Circuit Tester QM-1494

Designed for 12/24V vehicles, it tests polarity, voltage, short/open status, lights and more. Quickly test circuits without using jumper wires.

FREE TOOL STORAGE BOX FOR REWARDS CARD HOLDERS WHEN YOU SPEND $100 ON ANY OF THESE TOOLS HB-6302

HB-6302 VALUED AT $19.95

$12.95

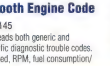
3-IN-1 Auto Tester QP-2258

Quickly check the condition of your 12V battery, charger or alternator. Compact & lightweight. 12VDC.

$59.95

Cat III Automotive DMM QM-1444

Features an inductive pickup for RPM measurement, dwell angle, and works with engines of 2 to 10 cylinders. 4000 count; AC/DC voltages up to 600V, RFM x1, x10.



$69.95

OBD2 Bluetooth Engine Code Reader PP-2145

No more cables! Reads both generic and manufacturer-specific diagnostic trouble codes. Checks vehicle speed, RPM, fuel consumption/ pressure and more.

$79.95

Digital Tachometer QM-1448

Measures up to 99,999RPM and can also count revolutions. Large LCD screen, laser pointer and min/max recall.

DOUBLE POINTS ON THESE REPLACEMENT LIGHTS FOR REWARDS CARD HOLDERS

ZD-0585

DOUBLE POINTS

FROM $9.95

Interior LED Retrofit Kits

Fantastic little kits to upgrade your car/caravan/boat interior lighting with LED technology. Each kit consists of an array of cool white LEDs on a board with 3M adhesive foam backing. 12VDC.

- Universal T10/211/BA9S

2.5W 260 LUMEN ZD-0585 **$9.95**
3.0W 310 LUMEN ZD-0587 **$12.95**
4.5W 450 LUMEN ZD-0589 **$14.95**

ZD-0750

DOUBLE POINTS

$12.95 ea

Festoon LED Globes CANBus Compatible

A range of 150 lumens ultra-bright white LED replacement "festoon" globes for car interior lights. Fully compatible with modern "CANBus" systems. 120° wide beam. 12VDC.

31MM ZD-0750
36MM ZD-0752
41MM ZD-0754

DOUBLE POINTS

FROM $39.95

ZD-0720

12V LED Trailer Lights

Stop, tail, turn and number plate illumination with red reflector panel. All in one solution for caravans, boat trailers, camping trailers etc. ADR approved. Sold in pairs.

- Screw stud mount

LIGHTS ONLY ZD-0720 **$39.95**
COMPLETE KIT ZD-0722 **$69.95**

**Kit includes 2x trailer lights, 7m pre-made trailer cable with 7pin flat trailer connector*

ZD-0746

DOUBLE POINTS

$29.95 ea

NEW

BA15 "3D" LED Globes

CANBUS COMPATIBLE

No more globe failure warning. These CANbus compatible globes feature a special "3D" type of LED lamp, which provides a wide 360° white light output. Perfect replacement for interior lights, and automotive lamps. 300 lumens. 12VDC.

BAY15D STOP/TAIL ZD-0746
BA15D INTERIOR/NAVIGATION ZD-0748
BA15S INTERIOR/PARK/REVERSE ZD-0749

SL-3490

DOUBLE POINTS

FROM $59.95

Slim Ballast HID Light Kits

HID provides far greater light output than standard automotive lights. This series of kits all feature a slim ballast design for ease of installation in engine bays and tight spaces.

- 12V 6000K colour temp
- 300% more light than halogen

Please ensure your lights are angled correctly.
These lights are not ADR approved.

H1 SLIM BALLAST HID KIT SL-3490 **$59.95**
H3 SLIM BALLAST HID KIT SL-3492 **$64.95**
H4 SLIM BALLAST HID KIT SL-3494 **$64.95**
H4 SLIM BALLAST HID HIGH + LOW KIT SL-3495 **$79.95**
H7 SLIM BALLAST HID KIT SL-3496 **$59.95**

15% OFF THESE TRAILER PRODUCTS FOR REWARDS CARD HOLDERS

Re-Wireable Trailer Connectors

A range of the most common 7 pin trailer plugs and sockets, featuring easy to use screw down terminals, corrosion resistant metal contacts and high quality UV stabilised plastics. *See website for wiring guide.*

$7.95 RRP EA.

FLAT PLUG PP-2050
FLAT SOCKET PP-2051
LARGE ROUND PLUG PP-2052
LARGE ROUND SOCKET PS-2053
SMALL ROUND PLUG PP-2054
SMALL ROUND SOCKET PS-2056

PP-2050

REWARDS CARD 15% OFF

Trailer Plug Adaptor Leads

About 300mm in length, and 6 versions available to fix up any mismatch of the 7 pin flat, 7 pin large round and 7 pin small round trailer connectors that you borrowed from your mate.

$15.95 RRP EA.

FLAT PLUG TO LARGE ROUND SOCKET PA-2061
FLAT PLUG TO SMALL ROUND SOCKET PA-2062
SMALL ROUND PLUG TO FLAT SOCKET PA-2063
LARGE ROUND PLUG TO FLAT SOCKET PA-2064
SMALL ROUND PLUG TO LARGE ROUND SOCKET PA-2065
LARGE ROUND PLUG TO SMALL ROUND SOCKET PA-2066

PA-2061

REWARDS CARD 15% OFF

WH-3091

REWARDS CARD 15% OFF

Trailer Cables

A 10 metre length sheathed in a tough black PVC jacket. Makes wiring easy. *See website for wiring guide.*

5 CORE WH-3091 **$29.95 RRP**
7 CORE WH-3090 **$39.95 RRP**

DEAL OF THE MONTH:

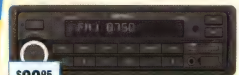
DEAL 1: 20% OFF — ANY PAIR OF SPEAKERS WITH PURCHASE OF ANY HEAD UNIT

DEAL 2: 50% OFF — ANY PAIR OF SPEAKERS WITH PURCHASE OF ANY HEAD UNIT + MONITOR

ADDITIONAL 20% OFF — REDUCED DEAL PRICE FOR REWARDS CARD HOLDERS* *Valid with Deal 1 or Deal 2

ENJOY UNLIMITED ENTERTAINMENT ON THE GO

Jaycar has been selling car audio products for almost 30 years. Our range of top quality car head units, speakers, amplifiers and accessories offers great value for money topped with strong engineering performance.



$99.95

In-Dash MP3 Player WITH RADIO QM-3781

Excellent value for money MP3 player with radio. Great for installing in tight locations such as a glove box. Features USB/SD card slot, PLL AM/FM radio and 4 x 20WRMS output.

$229

In-Dash Multimedia Player WITH USB AND BLUETOOTH QM-3788

Solid all-round multifunctional player with Bluetooth. Plays popular multimedia formats and produces superior sound for the road. Features NTSC/PAL video-out, subwoofer-out, Aux-in, DVD/CD, USB/SD card slot, PLL AM/FM radio, 4 x 20WRMS output and more.

TECH TIP! Phase Lock Loop (P.L.L) for extremely stable reception.

CS-2310

FROM $29.95

2-Way Car Coaxial Speakers WITH DOME TWEETERS

All sold in pairs. Great value for money.

4"	CS-2310	$29.95
5"	CS-2312	$34.95
6.5"	CS-2314	$39.95
6 X 9"	CS-2316	$54.95

CS-2400

FROM $79.95

Kevlar Car Coaxial Speakers WITH CAR DOME TWEETERS

All sold in pairs. High quality & performance.

4"	CS-2400	$79.95
5"	CS-2401	$99.95
6.5"	CS-2402	$129
6 X 9"	CS-2403	$149

7" TFT LCD Widescreen Monitor QM-3752

Features 1140(H) x 234(V) high resolution, NTSC/PAL, multi-source inputs, reverse image function. 12/24VDC. Add a wireless headphones (AA-2047) for complete in-car entertainment.

ALSO AVAILABLE:

WIRELESS STEREO HEADPHONES to suit QM-3752 AA-2047 **$39.95**

$119

DOUBLE POINTS ON THESE AUTOMOTIVE PRODUCTS FOR REWARDS CARD HOLDERS

DOUBLE POINTS

$129

9" In-Car LCD Colour Monitor QM-3761

Connect this 9" widescreen LCD to your source devices to entertain your passengers with movies or games. Featuring multi-source inputs and tilting bracket. Also doubles as a reversing camera monitor. 800 x 480 resolution. 12VDC.

DOUBLE POINTS

AA-3084

$9.95 EA

Eliminate Humming or Noise

These ground loop isolators (stereo) helps to eliminate ground loop problems in audio installations. Easily fastened to any surface or fitting using cable ties (use HP-1209).

3.5MM AA-3086

RCA AA-3084

DOUBLE POINTS

$14.95

Speaker to Line Level Converter AA-0482

Converts high level (high power) speaker signals back down to low level or <1volt so you can safely connect to amps without damaging them or other speakers. RCA socket out (stereo).

DOUBLE POINTS

FROM $14.95

AX-3662

Sound Deadeners

Enter a whole new world of sound. All are 330mm wide, extremely lightweight with adhesive backing for easy installation.

FOAM ABSORBER 66CM LONG AX-3682 **$14.95**

BUTYL DEADENER 90CM LONG AX-3687 **$29.95**

BUTYL/FOAM COMBO 66CM LONG AX-3689 **$29.95**

DOUBLE POINTS

$149

Under Seat Active 8" Subwoofer CS-2286

Add some bottom end to your car audio, even if you don't have room for a sub. MOSFET output stage for low distortion and noise. It will fit under a seat and is robust enough to take some knocks.

- 55WRMS power output
- Size: 360(L) x 250(W) x 80(H)mm

DOUBLE POINTS

$13.95

Automotive Crimp Tool Kit TH-1848

Cut & strip wire, crimp connectors and also cut a range of metric bolts. Includes 80 assorted connectors. A car enthusiast must have!

DOUBLE POINTS

$19.95

12-Piece Car Audio Tool Kit TH-2339

Avoid leaving scars on your cars. Designed to fit any car, this ABS pry tool kit is extremely useful for safely removing and installing car audio. Extremely sturdy tool!

$64.95

DOUBLE POINTS

Car Amplifier 8G Wiring Kit AA-0442

Everything you need for installing a car amplifier - down to the cable ties and screws. Save money on the individual parts. *See website for kit contents.*

ALSO AVAILABLE:

HEAVY DUTY SPEAKER CABLE 30M ROLL WB-1713 **$74.95**

HERE'S YOUR CHANCE TO MAKE A STATEMENT

Customise your vehicle interior with our high quality parts to match your unique personality. Upgrade your car into something unique and professional now.

SP-0774

FROM $19.95

Keyless Engine Start

Start your engine with just the press of a button. Choose from the standalone ignition switch or for more professional racer look, install the faux carbon fibre switch panel complete with missile launch switch, push button and indicator light. 12VDC, SPST N.O contacts.

STANDALONE SWITCH SP-0773 **$19.95**

COMPLETE SWITCH PANEL SP-0774 **$34.95**

"Condura" Style DC Rocker Switches

All switches come with double-LED illumination, a standard rocker cover and a standard range of decals to customise the switch to your application. Rated 20A @12V, 10A @24V. Typical decals include: windscreen wipers, horn, heater & many more. *See website for compatible laser-etched covers.*

WHITE SK-0910
RED SK-0912
BLUE SK-0914
ORANGE SK-0916

SK-0912

$12.95 ea

Quick Charge Your Electronic Devices

MP-3618

This twin USB charger socket is designed to be professionally panel mounted for automotive and marine applications. Comes complete with a protective cap with short-circuit protection. Easy installation.

- Input: 12-24VDC
- Dual USB outputs: 5VDC, 3.1A (shared)

$24.95

NEW

FREE ROADSIDE EMERGENCY KIT
ST-3267 Fully stocked roadside safety kit in a durable hard case. Ideal for all vehicles.

ST-3267 VALUED AT $24.95

AUTOMOTIVE CONNECTORS & PROTECTION

NOW $8.95
SAVE $2

Versatile USB Socket PS-2016 WAS $10.95

Easily add a 2.1A USB outlet under a wooden, fibreglass or metal dashboard complete with rubber plug moisture/dust cover. Alternatively, you can remove the actual USB insert to panel mount the USB socket. 12/24VDC.

$19.95

NEW

USB Charger Wiring Kit

PS-2017

Suitable for mounting on motorbikes, boats or open-top cars to power your USB devices. Includes weatherproof cover, 1.2m fused lead with SAE connectors for easy disconnects. 2.1A max output. 12/24VDC.

DOUBLE POINTS

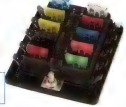
$24.95

2-Port USB Charger

MP-3616

Charge your USB devices in your car, boat or RV. Supplied with flush/surface/under dash mounting hardware. 1.0A + 2.1A USB ports. 3.1A max output. 12/24VDC.

DOUBLE POINTS



SZ-2008

FROM $19.95

10-Way Blade Fuse Block

Perfect for automotive or marine uses to keep fuse and wiring connections well protected from corrosion. Features a common supply rail and LED indicators for each fuse. 10 circuits @30A max.

Fuses sold separately.

STANDARD SZ-2008 **$19.95**

WEATHERPROOF SZ-2001 **$29.95**

DOUBLE POINTS

$23.95

Automotive Fuse Pack

SF-2142

Contains 120 standard size automotive fuses housed in a 6 compartment storage box. Includes 20 each of 5A, 10A, 15A, 20A, 25A & 30A fuses.

ALSO AVAILABLE:

FUSE PULLING TOOL TH-1973 **$1.95**

SZ-2081

DOUBLE POINTS

$34.95 ea

Heavy Duty Panel Mount Circuit Breakers

High quality units with multi-wire gauge inputs/outputs, perfect for high powered car audio, automotive or solar installations.

60A SZ-2081

120A SZ-2083

200A SZ-2085

CIGARETTE LIGHTER ACCESSORIES

PP-1970

FROM $6.95

Marine Grade Cigarette Lighter Connectors

High quality, weather and UV resistant. Ideal for adverse environments. Locking pins so stay plugged in when plug and socket matched. All 10A rated.

LINE PLUG PP-1970 **$6.95**

SOCKET, PANEL MOUNT PP-1972 **$6.95**

SOCKET, SURFACE MOUNT PP-1974 **$12.95**

NEW

$14.95

Cigarette Lighter Socket Splitter

WITH 2 X USB PORTS PP-2136

Power two 12V accessories and 2 x USB devices at the same time. Features a fused cigarette lighter plug on a 650mm lead, and mounting holes for a permanent installation. 12/24VDC.

- USB Ports: 2 x 5V 2.1A (total)

AUTO DIY MUST HAVE!

PP-2090

FROM $5.95

Merit Connectors

Commonly used in automotive power connectors. Smaller in size than existing cigarette lighter connectors, extremely rugged and provides higher reliability and current ratings.

15A UNFUSED PLUG PP-2090 **$5.95**

8A PLUG WITH CIGARETTE LIGHTER ADAPTOR PP-2094 **$6.95**

15A PANEL SOCKET WITH COVER PS-2092 **$9.95**

15A IN-LINE SOCKET WITH COVER PS-2096 **$6.95**

DOUBLE POINTS

$6.95

Waterproof Deutsch 2-Way Connector Set

PP-2150

Perfect for connecting up sensors/lights in the engine bay due to their superior corrosion protection and waterproof properties. 13A rated.

PP-2110

FROM $7.95

DOUBLE POINTS

Waterproof Plug & Socket Sets

Commonly used on many modern cars for wiring connections within the engine bay and other areas that are exposed to moisture. Features sealed interlocking parts and individual grommet seals on each wire. All 20A rated.

2-WAY PP-2110 **$7.95**

3-WAY PP-2112 **$10.95**

4-WAY PP-2114 **$16.95**

6-WAY PP-2116 **$19.95**

PT-4436

$12.95 ea

NEW

4-Way 15A Anderson Connectors

Housed in high impact and corrosion-resistant shell, these multi-connectors allow easy connection and disconnection of electrical equipments. Also available with latch for use in applications where shock or vibration may be severe.

4-WAY 15A PT-4434

4-WAY 15A WITH LATCH PT-4436

See terms & conditions on page 8.

BRING LIGHT OUTDOORS

Make your next outdoor adventure or work simpler and more enjoyable with the right lighting gears. Light up with our energy efficient 2-in-1 flood/worklights and keep your batteries charged to operate your favourite applicances off the grid.

Portable Lighting Deal:
VALUED OVER $288

BUNDLE DEAL INCLUDES:
2 X 10W 500 LUMENS 12VDC WORKLIGHT SL-2815 **$34.95 EA.**
1 X BATTERY BOX WITH 2 X CIG LIGHTER SOCKETS HB-8500 **$99.95**
1 X 12V 10A INTELLIGENT BATTERY CHARGER MB-3625 **$119**

$249
SAVE OVER $39

Premium Portable Lighting Deal:
VALUED OVER $717

BUNDLE DEAL INCLUDES:
1 X 100AH DEEP CYCLE GEL BATTERY SB-1695 **$429**
2 X 10W 500 LUMENS 12VDC WORKLIGHT SL-2815 **$34.95 EA.**
1 X BATTERY BOX WITH 2 X CIG LIGHTER SOCKETS HB-8500 **$99.95**
1 X 12V 10A INTELLIGENT BATTERY CHARGER MB-3625 **$119**

$629
SAVE OVER $88

ALWAYS STAY CONNECTED AND CHARGED ON THE ROAD

FREE CAR CHARGER FOR REWARDS CARD HOLDERS DC-1035
DC-1035 VALUED AT $17.95

$79.95

Always Keep in Touch
DC-1049
A standalone 80-channel 2W transceiver with CTCSS function. Features auto power-saving, dual watch, Vox, auto squelch function and low battery display. Includes a Li-Ion rechargeable battery and AC adaptor. Up to 10km range*.
**Typical line-of-sight range varies in built-up areas*

ALSO AVAILABLE:
CAR CHARGER DC-1035 **$17.95**
SPEAKER MIC DC-1062 **$24.95**

DOUBLE POINTS

Improve 3G/4G Phone Reception
Connect these 3G antennas with FME connector to your 3G/4G wireless modem to speed up wireless Internet and boost reception. Supports 850, 1800, 1900, and 2100 MHz. Magnetic base for use on car's roof.

5DBI 2M CABLE AR-3310 **$49.95**
7DBI 3M CABLE AR-3312 **$69.95**

FROM $49.95

AR-3310

DOUBLE POINTS

UHF Flexible Antenna Kits
Durable antennas with independent ground plane to ensure stable radiation pattern in all mobile mounting applications. Each features 5m pre-terminated cables with FME socket and PL259 adaptor so no tools are required.

4DBI, 407MM LONG DC-3073 **$64.95**
3DBI & 5.5DBI 450MM & 900MM LONG DC-3071 **$119**

DC-3073

FROM $64.95

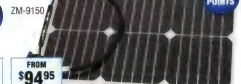
DOUBLE POINTS

$89.95

Amplified TV Antenna LT-3141
Excellent reception for local analogue and digital UHF & VHF TV, and FM radio. Compact and weather resistant. Includes built-in amplifier for up to 108dB gain, mounting bracket, mains and car charger. 12VDC.

$74.95

DOUBLE POINTS



ZM-9150

FROM $94.95

DOUBLE POINTS

90W Automatic Car Laptop Power Supply MP-3323
High efficiency, ultra-slim power supply with automatic output that connects to your car's cigarette lighter socket. Features a 2.4A USB port, LCD display and includes 13 interchangeable plugs to suit most laptops. *See website for compatibility*

Semi-Flexible Solar Panels
These 12V flexible solar panels offer performance at an affordable price. No heavy rigid frame makes them extremely light and portable. All units have a fully sealed terminal box with approx 900mm of power cable.

12V 18W ZM-9150 **$94.95**
12V 40W ZM-9152 **$199**
12V 100W ZM-9154 **$399**
12V 180W ZM-9156 **$649**

ATTENTION ALL TRADIES!

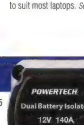
Jaycar TRADE CARD

IF YOU'RE A PROFESSIONAL AND REGULARLY PURCHASE ELECTRONICS GOODS FOR BUSINESS PURPOSES, YOU MAY BE ELIGIBLE FOR SPECIAL TRADE PRICES AT JAYCAR COMPANY STORES ON SELECTED ITEMS.
Conditions apply. See website for T&Cs.

SPEAK WITH OUR FRIENDLY STAFF AT YOUR LOCAL JAYCAR STORE TODAY & FIND OUT HOW.

15% OFF FOR REWARDS CARD HOLDERS

MB-3685



NEW

REWARDS CARD 15% OFF

250A Remote Battery Jumper Terminals
HM-3075 **$49.95 RRP**
This pair of remote battery jumper terminal provides convenient access to the vehicle battery for charging or jump starting. Suits cars, boats, trucks and caravans.

140A Dual Battery Isolator
Allows two batteries to be charged from your engine alternator at the same time. The isolator automatically engages and disengages depending on the charge condition of the start battery.
- Voltage rating: 12VDC (max 15VDC)
- Cut in/off voltage: 13.7/12.8 VDC

STANDALONE UNIT MB-3685 **$79.95 RRP**
COMPLETE KIT WITH WIRING HARDWARE MB-3686 **$149 RRP**

REWARDS CARD 15% OFF

Portable Pure Sine Wave Inverters
Suitable for a variety of mobile and permanent power installations, these inverters offer a host of additional features to improved performance and reliability under adverse conditions. All 12VDC inverters with USB port.

180W MI-5700 **$219 RRP**
360W MI-5702 **$269 RRP**
800W MI-5704 **$429 RRP**
1100W MI-5706 **$699 RRP**
1500W MI-5708 **$949 RRP**
2000W MI-5710 **$1199 RRP**

REWARDS CARD 15% OFF

BUILD YOUR OWN DIGITAL SPEEDOMETER

DRIVE SAFELY BY KNOWING YOUR SPEED
DOUBLE POINTS FOR REWARDS CARD HOLDERS

MINI PC + ARDUINO =
PCDUINO!
SPECIAL DEALS FOR REWARDS CARD HOLDERS

$9.95 DOUBLE POINTS

Hall Effect Sensor Module XC-4242

Sense magnetic presence, rotating wheels and magnets, door and arm sensors, etc nearby this sensor. Easy setup and use. 2.5 to 5.5V operation.

$39.95 DOUBLE POINTS

"Eleven" Board XC-4210

Based on the Arduino Uno but better. Top spec ATmega328P MCU, independent prototyping area, visible LEDs, and more. Firmly mounted Micro-USB connector to power your Eleven from most cellphone chargers!

NEW

$99.95 DOUBLE POINTS

1.3" Round LCD Module XC-4284

This innovative circular display with 65K colours is ideal for graphical gauges, needle-meters and robotics projects. Easy to program and interface to your projects. Includes an Arduino adaptor shield, a 5-pin header, jumper leads and a 4GB microSD card.

Want the ability to use a standard hard drive for bulk storage? Jaycar's pcDuino boards combines the features of a computer with a onboard SATA port and Arduino compatible headers. Preloaded with Ubuntu Linux for ease of use.

See website for details

DOUBLE POINTS

$3.50

Stackable Header Set HM-3207

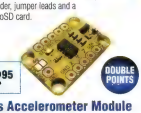
The perfect accessory to the ProtoShields and vero type boards when connecting to your Arduino compatible project.

- 2 x 8 pin and 2 x 6 pin included

$18.95 DOUBLE POINTS

Terminal Shield XC-4224

Breaks out all the Arduino headers to handy screw terminals, making it easy to connect external wires without using a soldering iron. Ideal for quick experiments or for robust connections!



$22.95 DOUBLE POINTS

3-Axis Accelerometer Module XC-4226

This module can operate in either +/-1.5g or +/-6g ranges, giving your project the ability to tell which way is up. Perfect for Arduino projects, robotics projects, vehicle dataloggers, and whatever else you can dream up.

- Independent X, Y, and Z axis outputs
- Can run from either 5V or 3.3V
- Zero-G free-fall detection

FREE 1.8M USB TO MICRO USB LEAD FOR REWARDS CARD HOLDERS
WC-7724 VALUED AT $9.95

$89.95

PcDuino V3.0 Nano XC-4352

REWARDS CARD OFFER
BUNDLE DEAL!
$239
SAVE OVER $28

DOUBLE POINTS

$3.95

Mixed 10-Piece Jumper Leads WC-6021

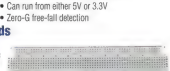
For use in arduino projects, school experiments, or RC and other hobbyist activities. 155mm long.

Solderless Breadboards

Two sizes of breadboards to suit all your project needs. For the "Ultimate Breadboard", use HP-9564 with HP-9514 (see below).

300 TERMINAL HOLES
PB-8832 **$12.95**

640 TERMINAL HOLES
PB-8814 **$19.95**



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Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to no stock in certain stores. Including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock.

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Savings off Original RRP. Prices and special offers are valid from 24 July - 23 August, 2015.

PRODUCT SHOWCASE

Maximising Solar PV Generation

Increasingly, when applications are submitted for the installation of solar photovoltaics, the network provider restricts the amount that can be installed and/or limits the amount of solar power that can be exported back into the grid.

GNT Engineering has developed and manufactured solutions that will allow customers to maximise their own power generation.

The ZED (Zero Export Devices) family of devices allows for the management of three-phase and single-phase solar PV systems, ensuring there is zero export of solar back into the grid.

The CED (Controlled Export Devices) is factory programmed where there are limitations on how much power can be fed back to the grid.

The devices constantly monitor how much electricity is being consumed from the grid.

The device in turn communicates with the inverters, specifying how much power they are required to generate.

This can be as little as 1% or as high as 100%.

The devices are web-enabled, allowing for live viewing of energy consumption and solar PV generation; data is also transmitted to the cloud where customers have access to all of their historical data.

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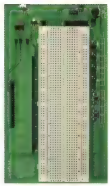
Website: www.gnteng.com.au

Gooligum's Raspberry Pi Prototyping Board



Into Raspberry Pi? Gooligum Electronics' new "Wombat" prototyping board makes it easy to create projects for this popular platform.

All of the Raspberry Pi's GPIO pins are clearly labelled and made readily accessible alongside a large breadboard with a 3.3V 500mA supply rail to power complex projects.

The Wombat provides eight analog inputs, plus LEDs and pushbutton switches, all supported by a supplied Python library.

It also adds a USB serial console to the Raspberry Pi – very useful when debugging!

A set of starter projects featuring an RGB LED, light and temperature sensors is bundled with each board.

For details go to www.gooligum.com.au

Built for tight spaces!

RS Components is now stocking the latest GearWrench 120XP ratcheting socket wrenches and spanners, which feature a precise 3° swing arc and long reach, with a compact head design to work quickly and efficiently even in inaccessible areas.

They're available in 1/4-, 3/8- or 1/2-inch square drive, with long handles giving lengths of 13mm, 21mm and 28mm respectively for enhanced reach. They also feature a low-profile teardrop-shaped head with 6-position adjustable angle, which enhances usability in tight spaces such as inside enclosures or behind panels. They are available individually, as a 3-wrench set, or in multi-piece socket sets containing a selection of SAE and metric size sockets.

The 120XP line also includes several ranges of combination spanners, including solid steel spanners in sizes from 6mm to 19mm, and flex head spanners with a choice of open non-ratcheting end or 0° offset box-type non-ratcheting end in sizes from 8mm to 19mm.

Ratchet gimbals with 1/4- and 3/8-inch square drive are also available, with rotation on two planes at various angles and fit conveniently in the palm of the hand to allow quick and easy tightening.

Contact:
RS Components Pty Ltd
25 Pavesi St, Smithfield NSW 2164
Tel: 1300 656 636
Website: http://au.rs-online.com

Party Lighting from Jaycar

Tempted to build the LED Party Strobe in this issue? Jaycar Electronics has a range of party lighting gear to go with it – and really make your next party MOVE!

Shown above are just some of them: the Stage DMX LED PAR Lights (ST-3600; $69.95) on the left; centre is the DMX Laser Light (SL-3451; $199.00); while on the right is the Portable Stage DMX light (ST-3604; $299).

While most lighting effects can be used in stand-alone mode, Jaycar also have DMX (digital multiplex) controllers to turn your lighting into an art form! Prices start at just $49.95.

You'll find these lighting products (and many more) in the 2015 Jaycar catalog or on their website.

Contact:
Jaycar Electronics
All stores and online TechStore
Tel: 1800 022 888 (orderline)
Website: jaycar.com.au

ElectroneX – The Electronics Design & Assembly Expo returns to Melbourne on 9 – 10 September, at Melbourne Park Function Centre.

Alternating annually between Melbourne and Sydney, this specialised event is the major focal point for the electronics industry in Australia.

It is designed to help professionals across a vast array of industry sectors to stay in touch with the latest electronics technology developments for systems integration and production electronics.

This year's event will reflect the move towards niche and specialised manufacturing applications in the electronics sector and will also cater for the increasing demand from visitors for contract manufacturing solutions.

A number of suppliers will also be participating for the first time which reflects the changing face of the electronics industry in Australia. There was also increased demand for 3D manufacturing technology at last year's expo in Sydney and this year's show has attracted new exhibitors from this rapidly developing sector.

Design, electronic & electrical engineers, OEM, scientific, IT and communications professionals and service technicians are invited to attend the event where they will find the latest technology driving future product & system developments.

This specialised trade event continues to enjoy strong support and is the pre-eminent electronics technology showcase and conference in Australasia.

ElectroneX
electronics design & assembly expo

Trade show

Electronex comprises a major trade show with over 80 companies exhibiting and demonstrating the latest new product releases for industry, scientific and commercial applications.

SMCBA Conference

The SMCBA – Electronics Design & Manufacture Conference is being held in conjunction with the exhibition and over 1000 trade visitors are expected to attend the expo and conference over the days.

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Emona at ElectroneX

Emona Instruments is demonstrating a number of new product releases at Electronex 2015, including the compact MegiQ affordable USB driven Vector Network Analyser.

This fully bi-directional two-port VNA allows detailed impedance measurements of antennas, components and circuits, covering 400-4000MHz, ie, all popular communication bands for GSM-LTE, GPS, ISM, Wifi, Dect etc. Other new product demonstrations include Rigol's DSA-875 7.5GHz spectrum analyser and the Rigol DG-5000 350MHz arbitrary function generators.

Emona offers a complete range of test and measuring instruments including oscilloscopes, function generators and counters, data acquisition, multimeters, power supplies, thermal imaging cameras and a range of products to support manufacturers including hipot and production testers and harness and cable testers.

Engineers should also visit Emona's new website at www.emona.com.au which offers users a powerful product filter capability making it quick and easy to find the right product for you application.

How Do You Choose a PCB Manufacturer?

At the QualiEco booth at Electronex 2015 (No A17), their Business Development Manager Tejas Shah will be happy to answer this question in detail. In essence, he says to look for the following criteria:

A PCB manufacturer must

1. Follow and maintain all necessary quality standards and accreditations
2. Maintain good quality consistently
3. Be economical - not necessarily the cheapest but must fetch value for money
4. Possess strong technical skill
5. Be prompt in communication
6. Be accurate and consistent in planning and delivery
7. Easily be accessible without any language barrier – just a phone call away.

Of course, there is much more to choosing a manufacturer than these broad-brush statements – each can be further broken down into many sub-headings and details.

Tejas says that QualiEco, which has served the Australian and New Zealand PCB market since 2003, fits every one of these criteria and looks forward to welcoming new customers and old at ElectroneX 2015.

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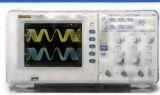

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ElectroneX: It's so much more than *just* an exhibition . . .

electronics design & assembly expo

While there are plenty of trade exhibitors to interest visitors to ElectroneX, trade visitors should also take advantage of the many seminars held in conjunction with the show. Following is a brief synopsis of some of the keynote seminars:

***Control of Noise, Signal Integrity & EMI in High Speed Circuits & Printed Circuit Boards* (Rick Hartley – RHartley Enterprises)**

AC currents flowing in a PC board create fields. When not controlled, these are the source of noise, electromagnetic interference ("EMI") and signal integrity ("SI") issues. Knowing how to design circuit boards to contain and control energy fields and knowing how to mitigate and control the effects of high speed devices is the key to successful design of low noise circuits.

This seminar looks at what we classically call "noise" but is in fact "intentional energy" which we fail to control and contain. It looks at why this happens and why some circuits are noisy; some are not.

***Enabling Implementation of Advanced Technologies* (Dr Denis Barbini - Universal Instruments' Advanced Process Laboratory)**

Universal Instruments Corp's Advanced Process Laboratory has developed a data-based focus for providing tools and case studies to implement advanced packaging designs into your assemblies. This seminar looks at identifying the impact of novel technologies in electronics manufacturing from fine pitch printing, to PoP, 01005, LGA/BGA and novel laminate materials.

Incorporating these enabling technologies present challenges – process change requirements, yield and reliability impacts. These technologies demand intense research and provide a unique perspective for design for manufacturability (DfM) and reliability (DfR).

***Flexible Electronics: Thin Film Solar Cells through Large Scale Printing.* (Scott Watkins - Kyung-In Synthetic Corporation)**

Flexible electronics is an emerging area of technology that is based on using new materials, particularly organic-based compounds, as semiconductors in devices such as displays and solar cells. This enables these devices to be light-weight, low-cost and flexible and they can be manufactured using processes such as roll-to-roll printing. Chemistry and Physics are at the core of these new technologies.

This will examine some of the industrially-focused research that is being done in this area within Australia by The Victorian Organic Solar Cell Consortium (VICOSC) - a research collaboration between CSIRO, The University of Melbourne, Monash University, BlueScope Steel, Innovia Films and Innovia Security.

It is supported by the Victorian State Government and the Australian Government through the Australian Renewable Energy Agency. *SC*

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KEYSIGHT
TECHNOLOGIES

Driveway Monitor

Pt.2: By JOHN CLARKE

Last month, we introduced our new Driveway Monitor and described how it worked. This month, we describe how to build, test and install it in your driveway. We also describe the various options so that you can build it to operate just the way you want.

BUILDING the Driveway Monitor is straightforward, with all parts mounted on two PCBs – a detector PCB coded 15105151 (104 x 78mm) and a receiver PCB coded 15105152 (79 x 47mm). As explained last month, the receiver PCB can be built in two versions. One version uses LEDs and a piezo buzzer to warn of vehicle arrival and exit, while the alternative version uses relays which are wired across the buttons of an external remote control PCB. This is then used to activate a remote-controlled mains switch.

Of course, there's nothing to stop you from building both versions of the receiver PCB if you want both sets of functions. As long as they're paired to the detector unit, they will both be triggered whenever a vehicle is detected in the driveway.

Detector assembly

Construction can start with the detector PCB assembly – see Fig.12. Begin by installing the HMC1021 magneto-resistive sensor (Sensor1) at centre-left. This is a surface mount device (SMD) and is soldered to matching pads on the top of the PCB.

To install it, first centre it on its pads making sure it is correctly orientated, then tack solder one of the corner pins. That done, check the alignment, adjust it if necessary and solder the remaining pins. The first pin can then be refreshed with some extra solder.

Don't worry if you get any solder bridges between the pins when soldering the device in. They can easily be removed afterwards using no-clean flux paste and solderwick. Check the connections under a magnifying glass to ensure that all the pins have been correctly soldered.

Once Sensor1 is in place, the resistors can be installed. Table 1 shows the resistor colour codes but you should also check each one using a digital multimeter before soldering it in place. Be sure to fit the correct value at each location.

Resistor R1 (top left) is normally shorted out by a track on the underside of the PCB. As stated last month, this resistor is omitted if you will be charging the NiMH cell from a solar

panel. Alternatively, you will have to cut the track and fit this resistor if you intend using a 12V or 9V DC plugpack to charge the cell instead of using a solar panel.

A 220Ω 1W resistor should be fitted for a 12V DC plugpack, while a 100Ω 1W resistor is used for a 9V DC plugpack. Don't forget to cut the PCB track underneath the resistor – a section of the track has been thinned so that it is easy to break.

The next step is to fit the two links and their ferrite beads to the right of Sensor1. It's basically just a matter of inserting a length of tinned copper wire through each bead, then bending the leads down on either side so that they go through the holes in the PCB.

Follow with the two 1N4004 diodes (D1 & D2), taking care to ensure they go in with the correct polarity. An IC socket should then be fitted for PIC microcontroller IC2, after which you can solder IC1, IC3 and REG1 directly to the PCB (or you can install them in IC sockets). Be careful not to get these three 8-pin devices mixed up.

The seven PC stakes can now be installed on the board. Five of these are located at the TP 5.5V, TP GND, TP1, Vout (next to IC2) and ANT (for the UHF antenna) positions, while the other two are fitted between coil L1 & REG1 to terminate L1's leads.

Now for the capacitors. Fit the ceramic and MKT polyester types first, then install the five electrolytics. Note that the 470µF and 220µF values must be low-ESR types. Make sure that all the electros are correctly orientated.

Mosfets Q1 & Q2 are next on the list, along with transistors Q3 & Q4 and regulator REG2. Be careful not to get the Mosfets mixed up – Q1 is an IRF540 N-channel type, while Q2 is an IRF9540 P-channel device.

There are three trimpots on the PCB and these can now be installed. VR1 is a 500Ω trimpot and may be marked as "501", while VR2 & VR3 are both 10kΩ trimpots and may be marked as "103". Be sure to push them all the way down onto the PCB before soldering their leads. LED1 can then be soldered in place with its anode lead (the longer of the two) going to its "A" PCB pad.

Follow with the 3-way DIL header. This part is installed to the right of IC2, with the shorter length pins going into the PCB. CON1, the 2-way screw terminal block, can then go in with its wire entry holes towards the left.

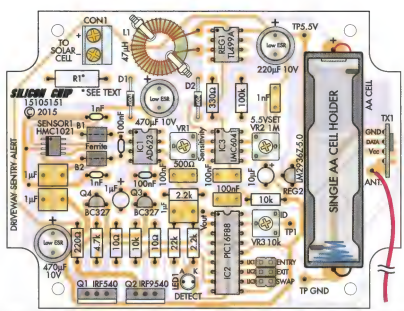


Fig.12: install the parts on the detector PCB as shown here, starting with the HMC1021 magneto-resistive sensor. Note that resistor R1 is omitted if you are charging the AA cell from a solar panel (see text).

The detector unit's antenna consists of a 168mm length of insulated hook-up wire. This should be fitted with a short length of heatshrink tubing at its far end so that it cannot short against any parts on the PCB.

Winding the inductor

Inductor L1 is wound on a powdered-iron toroid core using 32 turns of 0.5mm enamelled copper wire. Wind the turns on neatly in a single layer around the core (see photo), then trim and strip the wire ends of the enamel insulation. The leads are then soldered to the coil's PC stakes, after which the

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	330Ω	orange orange brown brown	orange orange black black brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	2	10Ω	brown black black brown	brown black black gold brown

toroid is secured in place using two cable ties that loop through through adjacent holes in the PCB.

The detector PCB assembly can now by completed by installing the cell holder, the UHF transmitter module and the antenna. The battery holder must be orientated as shown and is secured to the PCB using two self-tapping screws. Its leads are then cut short and soldered to their PCB pads at either end of the holder, with the red wire going to the "+" pad and the black wire to the 0V pad.

Take care with the orientation of the UHF transmitter module. Its pin designations are marked along one edge and it's just a matter of fitting it to the PCB with its antenna pin towards the bottom edge of the PCB (ie, towards the negative end of the cell holder).

The antenna consists of a 168mm length of insulated hook-up wire. Solder it to the antenna (ANT.) PC stake, then cover the connection with a short length of 1mm-diameter heatshrink tubing to prevent the lead from breaking at the solder joint.

Left: inside the solar garden light. Its AAA cell and white LED must be removed and the cable from the detector unit soldered across the battery holder contacts.

Fitting it in a case

The completed detector PCB can now be fitted inside a standard IP65 polycarbonate case measuring 115 x 90 x 55mm. This requires no preparation apart from drilling a 12.5mm-diameter hole in one end to accept a 3-6.5mm cable gland to feed through the wiring from the solar panel (or from a plugpack).

This hole is positioned 25mm up from the outside base of the case and is centred horizontally. Use a small pilot drill initially, then carefully enlarge the hole to size using larger drills and a tapered reamer until the gland fits.

That done, the PCB assembly can be lowered into the case and secured using four M3 screws that go into the threaded corner bushes. The Neoprene seal for the lid then needs to be placed inside the surround channel and cut to size. Note that the join in this seal must be along the lower, longer edge of the lid (the detector unit is later installed with the longer edges of the box running horizontally, so that the PCB sits vertically to ensure maximum sensor sensitivity).

If you only require a UHF transmission range of 40m or less, then the antenna wire can be positioned inside the case (see photo). Make sure that the the end of the antenna cannot short against the PCB or any of the parts (fit some heatshrink tubing over the end to insulate it).

Alternatively, for longer transmission ranges of up to 200m, the antenna wire can be fed out through a small hole in the bottom edge of the box and this hole sealed with silicone to keep water out.

Table 2: Capacitor Codes

Value	μF Value	IEC Code	EIA Code
1μF	1μF	1u0	105
100nF	0.1μF	100n	104
1nF	0.001μF	1n	102

Solar panel

A free-standing solar panel garden light will typically cost $2-3, with better quality units coming in at around $5. This will include the required solar panel, a single NiMH cell and (typically) a white 5mm LED. However, the NiMH cell is usually a AAA type and so won't be usable. Even if a AA cell is fitted, it will invariably be a low-cost (read low-quality) unit and you will be better off discarding it and buying a new one.

One problem is that the step-up voltage regulator on the detector board will not initially operate if the NiMH AA cell is discharged. That means that the cell must be charged before testing the unit.

If you don't have a suitable NiMH charger, then the solar panel can be used to charge the cell. It's simply a matter of removing the AAA cell and the white LED from the garden light, then running leads from the solar panel to the detector PCB and installing the AA cell in its holder. Note that the solar cell must be in sunlight in order for charging to take place.

Alternatively, you can temporarily run the leads from the solar cell to an external cell holder. The detector PCB can then be temporarily fitted with an alkaline AA cell for testing.

Detector PCB set-up

Having installed the detector PCB in its case, it's time to make a few adjustments. Just follow this step-by-step procedure:

(1) Adjust trimpot VR1 to mid-setting and set VR2 & VR3 fully anticlockwise.

(2) Install IC2 in its socket, making sure that it's correctly orientated. Fit the other ICs and REG1 if you've installed sockets for these as well.

(3) Fit the AA cell to its holder, then measure the voltage between the TP5.5V and GND PC stakes and adjust VR2 for a reading of 5.5V. If you cannot get sufficient voltage, it may be due to the AA cell. Check the cell voltage and if that's OK, try momentarily removing the cell and reinserting it so that REG1 starts properly.

(4) Check that there is +5V at pin 14 of IC2 (this could be from 4.85-5.15V, depending on the particular regulator used for REG2).

(5) If all is OK, the unit should now be ready to detect magnetic field variations (about 10s after the cell is installed). Orientate the unit so that the PCB is vertical and check that the bicolour LED lights red or green if the unit is rotated by a few degrees. The LED should then go out again after a brief period if the unit is kept stationary.

(6) Check that the unit can detect a pair of steel pliers if they are passed close to the sensor. LED1 should light red if the pliers are passed in one direction and green in the other.

Note that, in practice, IC1's output should not swing too close to the supply rails. Output swings close to 0V (<0.3125V) or close to 5V (>4.6875V) will be indicated by the bicolour LED alternately flashing red and green at a 1s rate.

If that happens, there is either a high magnetic field in the vicinity of the sensor (eg, a magnet) or IC1's gain is set too high by VR1.

The detector PCB is secured to integral threaded corner posts inside its IP65 case. Be sure to install the NiMH cell the right way around and note that the cell must be charged before testing the unit.

Our prototype had the cable gland fitted to a side panel but fitting it to the bottom panel would be preferable in many installations.

Diagnostic mode

Now install a jumper between LK2 & LK3 as shown on Fig.13. This sets

The detector unit must be attached to a non-metallic post or wall adjacent to the driveway. You can either mount the solar panel on top of the detector or leave it in the garden light housing as shown at right. Make sure that the solar panel is mounted in a sunny location.

the unit into diagnostic mode which is used for testing only, since other circuit functions are disabled and the circuit draws a relatively high current while it's in place.

By installing this link, variations in IC1's output can be monitored using a multimeter connected between Vout and TP GND. You can either rotate the detector unit or swipe a pair of steel pliers close to the sensor and then check that the DMM shows the resulting variations in IC1's output.

Note: this mode is not used when adjusting IC1's gain. That's done later by trial and error when the detector unit is installed in the driveway.

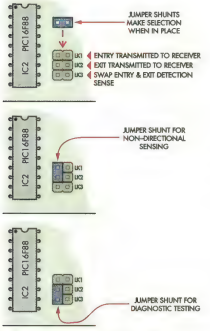


Fig.13: this diagram shows the linking options for the detector PCB. The diagnostic jumper between LK2 & LK3 is for test purposes only.

Setting the identity

The diagnostic mode is also used when adjusting identity trimpot VR3. If you have only one detector unit, simply set VR3 fully anticlockwise for a UHF transmission identity of "1".

If you have more than one detector unit, they will each need a different identity to avoid interference. It's just a matter of installing the diagnostic link and adjusting VR3 so that the voltage at TP1 matches an identity setting voltage as shown in Table 3.

Linking options

As mentioned last month, jumpers LK1-LK3 determine the information that's encoded into the UHF transmission sent to the receiver – see Fig.13. As shown, LK1 is installed for arrival (entry) notifications, while LK2 gives departure (exit) notifications. Depending on your requirements, you can either install both these links or leave one or the other out.

For example, let's say that you build the relay version of the receiver and you want to trigger a remote-controlled mains switch for a set period of time only when a vehicle arrives. In that case, you would install a jumper on LK1 to signal vehicle entry but no jumper link for LK2 (exit).

If you want to trigger the remote for both directions, install both LK1 & LK2.

LK3 is installed if the arrival and departure indications are incorrect (it simply swaps them around), while installing a jumper between LK1 & LK2 sends a non-directional indication to the receiver.

Note that the link settings operate in exactly the same way for both receiver versions.

Detector unit installation

The detector unit can be installed alongside the driveway on a post or wall. Before mounting it though, you should check that the unit will reliably detect a passing vehicle.

That can be done by temporarily placing the unit on a wooden box or stool so that it's about 60-80cm above ground (ie, so that it lines up with the metal body of a car). If you like, you can leave the diagnostics jumper in place so that you can check that Vout varies as a vehicle passes by.

If it does, remove the diagnostics jumper and check that the detector unit lights the green LED for one direction of the vehicle and the red LED for the other direction. If the vehicle isn't reliably detected, adjust sensitivity trimpot VR1 clockwise to increase IC1's gain (but don't set VR1 fully clockwise). Conversely, wind VR1 anti-clockwise to decrease the gain if the red and green LEDs in the bicolour LED flash alternately at a 1s rate.

In practice, VR1 should be set somewhere between fully anticlockwise and about three-quarters clockwise in order to achieve reliable detection.

During this test procedure, the detector must be kept still, otherwise it will detect changes in the Earth's magnetic field due to its own movement. If that happens, the tracking thresholds then need to readjust so that they sit equally above and below the amplified sensor voltage and this could take some time (eg, over a minute).

If you want the tracking thresholds to readjust faster, you can remove the AA cell for a few seconds and then reinstall it. By doing this, the thresholds will readjust within 10s. Another way

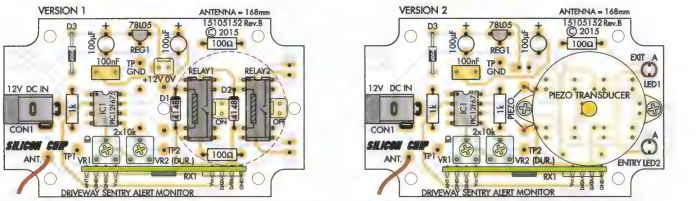
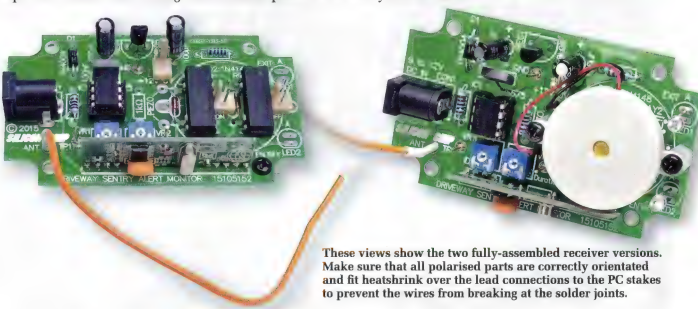


Fig.14: the PCB parts layouts for the two receiver versions. Build Version 1 if you want to activate the buttons on a separate remote control PCB (eg, to control a UHF remote mains socket). Alternatively, build Version 2 if you only require an audio/visual warning when a vehicle passes the driveway detector unit.



These views show the two fully-assembled receiver versions. Make sure that all polarised parts are correctly orientated and fit heatshrink over the lead connections to the PC stakes to prevent the wires from breaking at the solder joints.

is to change LK3 (ie, either install the jumper or remove it). Each time LK3 is changed, the detection thresholds re-track within 10s.

Once it's working, the detector unit can be permanently mounted using the holes provided in the box corners (these holes are accessible when the box lid is removed). These holes could either be used to directly secure the unit or you could use them first to attach a bracket (preferably made from non-magnetic material) which is then attached to a wall or post.

Connecting the solar panel

The solar panel is connected to the detector via a length of figure-8 cable. This cable is passed through the cable gland, either in the side or bottom edge of the case, and terminated in screw terminal block CON1. Be sure to connect the cable with the correct polarity (the red wire that's connected to the solar panel is positive).

Be sure also to disconnect the solar panel from the LED inside the garden light fixture. The fixture should then be installed nearby in a sunny part of the garden, to ensure that the solar panel gets full sun during the day.

If that arrangement isn't convenient (eg, you don't have a nearby garden bed), then the solar panel can be removed from the light fixture and mounted separately. It may even be possible to mount it on top of the detector unit using a suitable non-metallic bracket, as shown in the photos.

Finally, use neutral-cure silicone to seal the wire entry into the cable gland to keep moisture out of the case. The same goes for any other possible water-entry locations (eg, screw mounting holes for brackets etc).

Receiver assembly

Fig.14 shows the assembly details for the two receiver versions. Version 1 has the reed relays to trigger a remote control PCB, while Version 2 has the piezo buzzer and LED indicators for audio/visual warnings only.

As previously mentioned, if you want both sets of functions, you will have to build both versions and set them to the same identity as the receiver. Note that the LEDs and piezo buzzer must be omitted if you build the relay version (Version 1), while the relays and diodes D1 & D2 are omitted from Version 2.

In most cases, it's just a matter of selecting which version you want to build and assembling the board to match its layout. Install the resistors first, then install diode D3 (1N4004). D1 & D2 (1N4148) should then be fitted if you are building Version 1. **Note that D2 must be installed about 3mm proud of the PCB, since it needs to be later pushed to one side to make room for a polarised 2-way header.**

The PC stakes are next on the list and these are installed at TP GND, TP1,

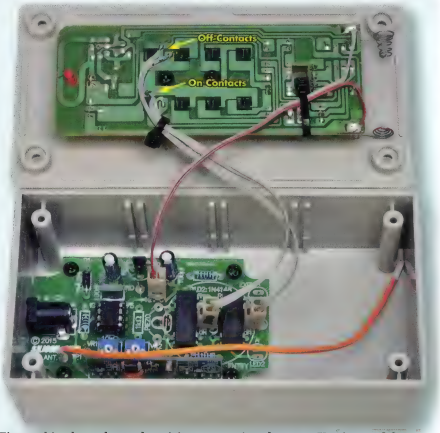


Fig.15: this photo shows the wiring connections between Version 1 of the receiver PCB and the remote used for the Jaycar UHF mains socket. You will need to scrape away the solder masking from some of the pads on the remote PCB before soldering the leads.

A UB3 plastic case is used to house Version 1 of the receiver PCB and its companion remote PCB. The front-panel label is optional.

TP2 and the antenna (ANT.) terminal. If you are building Version 2, two extra PC stakes can be fitted to terminate the piezo buzzer leads (or you can elect to solder these leads directly to the PCB).

The capacitors can be installed next. Note that for Version 2, the electrolytic capacitors must be no more than 14mm high so that they don't foul the lid of the case.

An 8-pin socket should now be fitted for IC1. Make sure that the socket sits flush against the PCB before soldering its pins, then install REG1 (78L05). The two relays can then be fitted if you are building Version 1. Check that these are orientated correctly (ie, notched ends aligned as shown on Fig.14).

Version 1 also requires three polarised pin headers. Install these now, bending diode D2's leads to the right as shown in one of the photos to clear the header that's fitted between the two relays.

Follow with the DC socket and trimpots VR1 & VR2. The two LEDs can then be installed for Version 2 (red for LED1 and green for LED2). These two LEDs must be installed with 11mm lead lengths, so that the tops of their lenses are 16mm above the PCB. That's easily done by pushing each LED down onto an 11mm-high cardboard spacer that's slid between its leads before soldering it in place.

Piezo transducer mounting

The piezo transducer used in Version 2 mounts on two M3 x 9mm tapped spacers. These spacers are secured to the PCB using M3 x 6mm screws. The piezo transducer is then secured in place, again using M3 x 6mm screws. You will have to drill out the transducer's mounting tab holes to 3mm diameter to accept the M3 screws.

Once the transducer is in place, trim its wires to about 25mm, slip some 15mm lengths of 1mm-diameter heatshrink tubing over the wires and solder them to the adjacent PC stakes. The heatshrink can then be slid over the soldered connections and shrunk down to prevent the wires from breaking.

UHF receiver

You can now complete the PCB assembly by installing the UHF receiver module and the antenna. It must be orientated with its antenna pin to the left (ie, towards the DC socket). As with the transmitter, the pin designations are printed on the module.

Once its in place, solder a 168mm-long insulated wire to the antenna PC stake. The soldered connection should then be covered with heatshrink tubing to prevent the wire from breaking.

Version 1 final assembly

The Version 1 PCB receiver assembly is housed in a UB3 plastic case (130 x 68 x 44mm) along with the PCB from the mains socket's remote. We'll describe how the two are wired together shortly, after the PCBs have been mounted in position.

The receiver PCB mounts in the base of the case on M3 x 6mm tapped spacers. That's done by first placing the PCB inside the case with the DC socket flush against one end, then marking out the four corner mounting holes. These holes are then drilled to 3mm and countersunk on the outside of the box using an oversize drill.

A 9mm hole must also be drilled in the end of the case to provide access to the DC socket. This hole is positioned 17mm up from the base of the case and centred horizontally. You will also have to drill a small hole in this end of the case for the antenna lead if you

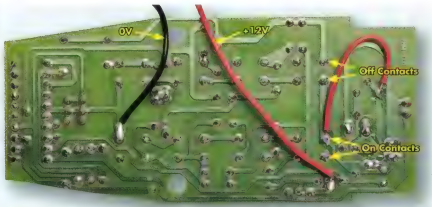


Fig.16: here's how to make the connections to the Altronics UHF remote PCB. The red and black leads shown are all part of the original wiring.

require a range greater than about 40m.

Once that's been done, the spacers and the receiver PCB can be secured in position using M3 x 10mm countersink screws and nuts. The antenna lead can be either run around the inside perimeter of the case or fed out through its exit hole. As with the detector unit, make sure that the end of the antenna cannot short against the PCB or any of the parts.

The next step is to mount the remote control PCB. Suitable remote-controlled mains sockets include the Jaycar MS-6142 and MS-6145 units and the Altronics A0340.

Before removing the remote's PCB module, the remote control mains socket should be set to operate as described in the instructions. This will familiarise you with the way the unit works and allow you to set the channel number and test its operation.

Once you've done that, the hand-held remote can be disassembled. The Jaycar remote has one screw located beneath the battery cover and when this is removed, the two halves of the remote case can be cracked open along the sides with a screwdriver. Similarly, the Altronics remote has two screws under the battery compartment lid and removing these allows you to split the case.

It's then just a matter of removing the remote PCB and connecting leads from the polarised headers on the receiver PCB. The 12V header is wired to the remote's supply rails, while the other two headers are connected to the remote's on and off button contacts for the selected channel. That way, when the Driveway Monitor is triggered, one reed switch closes briefly to turn the remote-controlled mains switch on. The other then closes briefly a few minutes later to turn the mains switch off.

The leads from the headers can be run using 120mm lengths of light-duty hook-up wire. At the header end, it's just a matter of crimping the wires into the crimp lugs and then lightly soldering them before pushing them into the header shell until they are captured by the tag springs. Use red & black leads for the 12V header and make sure you get the polarity correct.

Figs.15 & 16 respectively show the connections to the Jaycar and Altronics remote PCBs.

On the Jaycar unit, it will be necessary to scrape away the solder masking from the PCB before soldering the connections. Once all the wires are in place, fit cable ties around the switch wires to prevent them from pulling away from the PCB. It's also a good idea to use neutral-cure silicone or hot-melt glue to hold the wires in place.

In the case of a doorbell remote, it's simply a matter of wiring the first reed switch across the switch contacts. This reed switch could also be used to trigger a burglar alarm.

The remote PCB is mounted on the underside of the case lid. Both remotes have two holes that can be used as mounting points, although the Jaycar unit's holes will need to be enlarged to 3mm. In each case, the unit is mounted on M3 x 9mm tapped spacers and secured using M3 x 6mm machine screws.

We used countersink-head screws for the lid so that the heads sit flush with the panel to allow a front-panel label to be attached. Position the mounting holes so that the remote PCB is centred on the lid, then mount the PCB in position and plug the various leads into their corresponding sockets on the receiver PCB.

Version 2 final assembly

The Version 2 receiver is housed in a UB5 case (83 x 54 x 31mm), making it more compact than the Version 1 unit. In addition, no mounting hardware is required for Version 2 since the PCB simply clips into slots in the integral side channels in the case.

Before installing the PCB, you will have to drill a 9mm hole for the DC socket. This should be positioned 20mm up from the base and centred horizontally. As with Version 1, drill a small hole for the antenna lead if you require a range greater than about 40m (ie, up to 200m). You can then clip the receiver PCB into position and either feed the antenna wire through its hole or run it around inside the case.

Finally, three holes have to drilled in the lid – two for the indicator LEDs

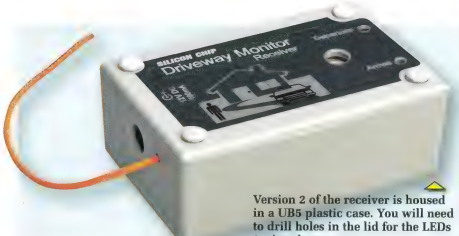
Unit Pairing

A feature of the Driveway Monitor is "pairing", whereby each detector and receiver pair are given a unique identity. This allows up to eight different pairs to operate in the same vicinity, which means that you can have multiple Driveway Monitors installed on your property.

Pairing is set by adjusting trimpots VR3 in the detector unit and VR1 in the receiver to give matching voltage readings at their respective test points – see text & Table 3.

Table 3: Identity Voltage Settings

Identity	Minimum Setting	Maximum Setting	Recommended
1	0V	0.47V	0-0.31V
2	0.78V	1.09V	0.94V
3	1.41V	1.71V	1.56V
4	2.03V	2.34V	2.19V
5	2.66V	2.97V	2.81V
6	3.28V	3.59V	3.44V
7	3.91V	4.21V	4.06V
8	4.53V	5V	4.69-5V



Version 2 of the receiver is housed in a UB5 plastic case. You will need to drill holes in the lid for the LEDs & piezo buzzer.

Fig.17: this full-size artwork can be used as a drilling template for the Version 2 case lid. You can either copy it or download it as a PDF file from the SILICON CHIP website.

and one directly above the piezo transducer to let the sound out. You can either copy and use Fig.17 as drilling template or you can simply measure the hole locations and then mark their positions on the lid (the artwork is also available for download as a PDF file from the SILICON CHIP website). Drill 3mm the holes for the LEDs and a 6mm hole for the piezo transducer.

Testing (both versions)

Before applying power, make sure that IC1 is out of its socket and that all parts are correctly orientated. That done, apply power from a 12V DC plugpack and check that there is 5V between pin 1 of IC1's socket and the GND PC stake (4.85V to 5.15V is acceptable). A reading below 4.85V could mean that there is a short circuit somewhere or an electrolytic capacitor could be the wrong way around.

If the 5V supply is correct, disconnect power and plug IC1 into its socket (make sure it's correctly orientated). Once it's installed, reapply power and adjust VR1 to set the receiver's identity by monitoring the voltage on TP1.

Typically, VR1 is set fully anticlockwise to select identity 1. If you require a different identity (eg, to match a second detector unit), set it to match the detector as shown in Table 3.

VR2 sets the alert duration. For Version 1, this is the time period between when relay 1 briefly turns on and closes the remote's ON contacts to when relay 2 briefly turns on and closes the remote's OFF contacts (ie, it determines how long the remote mains socket is switched on). This time duration ranges from about 20s when VR2 is set fully anticlockwise to about five minutes when VR2 is fully clockwise.

You can quickly set the duration by monitoring the voltage between TP2 (ie, VR2's wiper) and TP GND. Adjust VR2 for 5V on TP2 for five minutes, 2.5V on TP2 for two and a half minutes and 1V on TP2 for one minute, etc.

Alternatively, for Version 2, VR2 adjusts the length of the entry and exit tones from 1-5s. Each indicator LED then lights for the length of its corresponding tone and stays on for about 15s after the tone ceases.

All that remains now is to check that the unit is triggered whenever a car passes by the detector unit. If the unit fails to trigger or is unreliable, check that the detector unit is functioning properly as outlined in its installation procedure above. If that's OK, check that the detector and receiver identities match.

Finally, if you still have problems and the antennas are inside the cases, feed them outside and straighten them out to improve the range. They should also be orientated the same way; ie, both vertical or both horizontal. SC

Front Panel Labels

The front-panel labels are optional. They can be made by downloading the relevant PDF files from the SILICON CHIP website and then printing each one as a mirror image onto clear overhead projector film (use film that's suitable for your printer). By printing mirror images, the toner or ink will be on the back of each film when it's fitted. The labels can be secured using clear silicone adhesive.

Alternatively, you can print onto a synthetic Dataflex sticky label if using an inkjet printer or onto a Datapol sticky label if using a laser printer.

(1) For Dataflex labels, go to: www.blanklabels.com.au/index.php?main_page=product_info&cPath=49_60&products_id=335

(2) For Datapol labels go to: www.blanklabels.com.au/index.php?main_page=product_info&cPath=49_55&products_id=326

Modified Sampling Rate For Identities 5-8

Recent testing on the Driveway Monitor has shown that a vehicle can, on rare occasions, slip past the sensor unit undetected. To do this, the vehicle has to be travelling at over 20km/h and it has to pass the detector between the 300ms sampling intervals.

This will not be a problem for most household driveways but it could be a problem on rural driveways where speeds can easily exceed 20km/h.

To overcome this problem, we have increased the sampling rate to 150ms for identities 5-8 (ie, where TP1 is set for over 2.5V). So if vehicle speeds are likely to exceed 20km/h, set the unit to one of these higher identities.

Identities 1-4 retain the standard 300ms rate. A disadvantage of the 150ms sampling rate is that quiescent current from the AA cell increases from about 3mA to 6mA.

Correction: the parts list for the detector unit (see July 2015 issue) incorrectly lists IC1 as an AD723AN. It should be an AD623AN, as shown on the circuit.

KCS TraceME

LoRa ™ Internet of Things

KCS has extended their successful TraceME product line with an advanced module, targeted for worldwide mobility in the Internet of Things era. The latest development of the TraceME GPS/GPRS Track and Trace module will combine the RF location based positioning solution with the LoRa™ technology. This combination offers 'smart objects' being even smarter, since LoRa™ enables long range, battery friendly communication in a wide variety of (M2M) applications. Supporting GPRS/SMS and optional 3G, Wi-Fi, Bluetooth LE, ANT/ANT+ and iBeacon™ provides easy integration with existing wireless networks and mobile apps. Other variants in the high/mid-range and budget-line will follow soon.

ANTI-THEFT module based on RF

KCS TraceME product line offers an intelligent location based positioning solution for indoor and anti-theft applications.The solution is based on RF with an intelligent algorithm of measuring the propagation time of transmitted (proprietary protocol) signals. Unique features are: minimum size (46x21x6.5mm), weight (7 grams for fully equipped PCB) and a standby battery lifespan of more than 10 years. Listen before talk' algorithm makes it practically impossible to locate the module, which secures the valuable vehicle or asset. Supporting GPRS/SMS and optional 3G, Wi-Fi, Bluetooth LE, ANT/ANT+ and iBeacon provide easy integration with existing wireless networks and mobile apps.

www.Trace.ME

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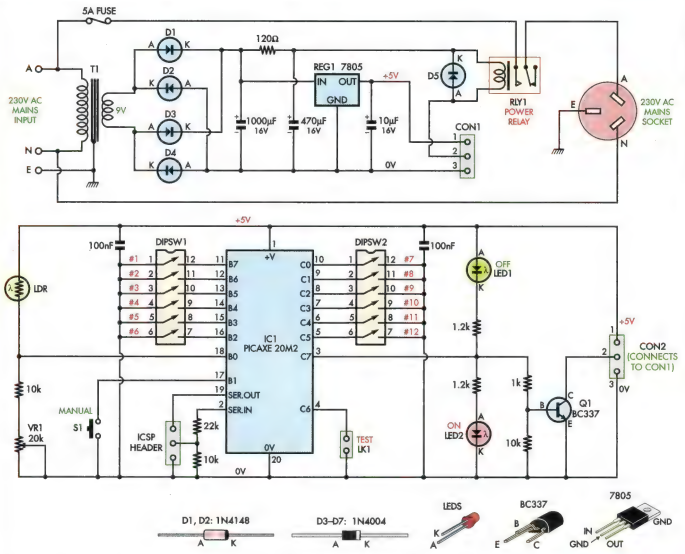
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



PICAXE-based mains timer

This mains timer is used to switch a room lamp on and off several times during the evening to give the impression that your home is occupied. The timer uses an LDR to sense darkness and then steps through 12 switches, pausing for 30 minutes at each step. The switches can be set so that the lamp is turned on or off during the 30-minute pause. The complete lamp cycle lasts six hours.

Various lamp switching patterns can be set up by using different combinations of switches. Placing extra timers with different patterns in other rooms will enhance the overall effect.

The design has a microcontroller board mounted above a power supply board and these connect via 3- way terminals CON1 & CON2. The mains wiring, power terminals and power relay are external to these boards. Connect them using 250VAC-rated cable and cover all exposed power connections.

Any standard extension lead may be cut in half to become the mains input plug and output socket. The enclosure is fitted with a clear lid to allow the two status LEDs to be viewed and the LDR to detect ambient light levels.

Ian Robertson is this month's winner of a $150 gift voucher from Nuts & Furbies

The microcontroller board uses a PICAXE20M2 (IC1) to control the 12 time periods using the software "time" variable to count elapsed time in seconds. There are 14 input pins on IC1 that have internal pull-up resistors enabled in the software. These inputs monitor the 12 step

switches in DIPSW1 & DIPSW2, the manual pushbutton S1 and also the test link LK1. Each press of the manual pushbutton toggles between the standby and stepping modes. To prevent false readings, light levels are not checked while the stepping mode is active.

Other pins used on IC1 are analog input pin 18 which monitors the light dependent resistor (LDR), where the voltage will be low when dark and high when light. The switching point can be adjusted using 20kΩ trimpot VR1. There is a single output signal from pin 3 driving BC337 transistor Q1, the power relay RLY1 and status indicators LED1 and LED2.

This output is turned on when the timer is stepping and finds one of the DIP switches on. The LDR should be a low resistance type (Jaycar RD-3485, Altronics Z-1621 or similar).

The power supply board provides 12V DC and 5V DC supplies using a 9VAC transformer, diode bridge D1-D4, a 1000µF filter capacitor and 7805 regulator REG1. The 12V DC supply feeds the power relay while the 5V supply feeds the microcontroller. The circuit limits current in the power relay coil, using the charge in a 470µF capacitor to actuate the relay and the 120Ω resistor to hold the relay closed at a reduced current. You need a type 2840 transformer, either Jaycar MM-2017, Altronics M-2840L or similar.

The recommended power relay to use is either the Jaycar SY-4040 or Altronics S-4211. Both relays are for mains use with 12V coils and contacts rated for 30A at 240VAC. The 5A fuse in the Active mains lead may be increased to10A if the load requires it. For safety, use heatshrink tubing on the relay connections and fuseholder connections.

Since the complete lamp cycle lasts six hours, testing the timer could be a drawn out process. Fitting a jumper on LK1 reduces the 30-minute step time to three seconds and this allows the complete timer cycle to be easily tested.

Consult the program notes if you wish to alter the default 30-minute and 3-second step times. You will find details on customising your unit using the same time for all steps or using different times for the odd steps and even steps.

The circuit shows an ICSP header to download the software into the microcontroller (IC1) and uses pin 2 as the serial input and pin 19 as the serial output signal. You need a special PICAXE serial or USB cable to transfer the *steptimer_20m2.bas* Basic program (available from www.siliconchip.com.au).

Ian Robertson,
Engadine, NSW.

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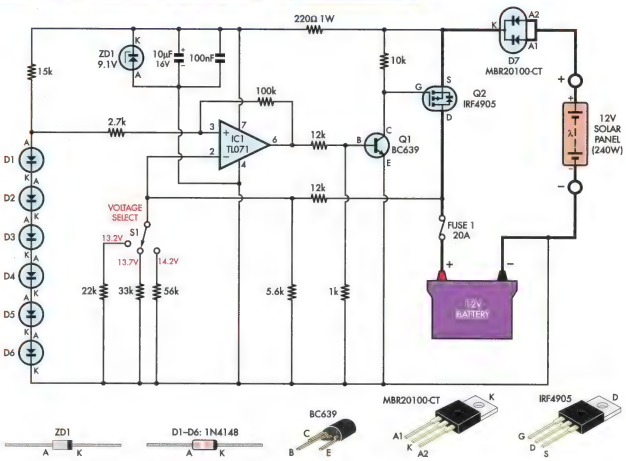

Simple solar charge regulator for campers

This simple circuit can be used to charge a 12V lead-acid battery from a 12V solar panel with a rating of up to 240W. It uses an IRF4095 P-channel Mosfet controlled by a TL071 op amp connected as a comparator.

The control circuit is powered by the combination of the solar panel and the battery under charge, via a 220Ω resistor and ZD1, a 9.1V zener diode. The string of six diodes, D1-D6, provides a reference voltage of about 3.7V to the non-inverting input, pin 3, of IC1. The battery voltage is monitored via a 12kΩ resistor and a set of resistors selected by rotary switch S1 to give a range of end-point voltages ranging from 13.2V to 14.2V.

In practice, you should set the switch to suit the battery type, eg, 13.7V to suit a sealed lead acid (SLA) battery and 14.2V to suit a car battery. The charging voltage should be checked with a DMM during operation.

Initially, IC1's output will be high (ie, pin 3 will be above pin 2), Q1 will be turned on and Mosfet, Q2, will be turned on to charge the battery. When

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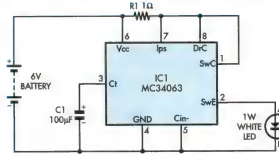

Simple switchmode LED flasher

Elsewhere in this issue, we feature a 555-based LED flasher circuit in the LED Party Strobe article but this one is much simpler, based on an MC34063 switchmode driver, one resistor and one capacitor; only the now obsolete National Semiconductor LM3909 LED flasher is simpler.

The MC34063 is used by the millions in low-power switchmode circuits for phone chargers and so on and in those circuits it is surrounded by quite a few other components, depending on the current and voltage output. In this LED flasher circuit though, the internal switching transistors of the MC34063 are more than capable of handing the power requirements unaided.

This device contains a voltage reference, comparator, controlled duty cycle oscillator with an active peak current limit circuit, driver and a high current output switch, all in an 8-pin DIP. Here the MC34063 is set to drive a 1W white LED at about 350mA, with the LED current controlled by the 1Ω resistor (R1) between pins 6 & 7.

At the beginning of a cycle, timing capacitor C1 begins to charge and the LED current rises rapidly. When the voltage across R1 rises above 330mV, the current limit block in the IC provides additional current to charge the timing capacitor C, causing it to rapidly reach the upper oscillator threshold, at which point the output switch turns off and C1 discharges.

The flash rate is about 4Hz with C1 set to 100µF and the duty cycle is about 5%. Reducing the capacitor's value will increase the flash rate and vice versa.

From EDN: see http://www.edn.com/design/led/4432212/HB-LED-flashing-beacon-repurposes-switching-regulator

the battery voltage subsequently rises to 14.2V (if this is the selected cut-off voltage), pin 2 of IC1 will go above pin 3 and pin 6 will go low, turning off Q1 and Q2. It will stay that way until the battery voltage falls to 13.6V and then IC1 will turn Q1 & Q2 on again, ie, the comparator has a hysteresis of 0.6V, as set by the 100kΩ resistor between pins 6 & 3.

D7 is a paralleled MBR20100-CT Schottky diode pair and is included to prevent the battery discharging via the substrate diode of Mosfet Q2 and back through the solar panel. Both D7 and Mosfet Q2 should be mounted on a small heatsink.

Fuse 1 should have a rating of 20A and is included as a safety feature in case of a circuit fault condition. Note that the panel itself will self-limit the charge current to about 14A in the case of a 240W panel and proportionally less for smaller panels.

David Francis, ($50)
Kilburn, SA.

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Published in Dec 2012

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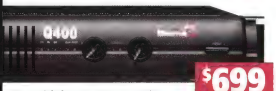

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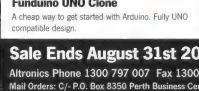

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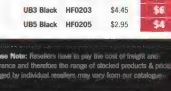

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LED PARTY STROBE MK2

By ROSS TESTER

Back in January 2014, we published a LED Party Strobe – something which we had been assured couldn't be done! It not only worked, it was very popular. Now we have an even simpler – and much cheaper – approach using a standard 230VAC 30W LED floodlight which can be purchased quite cheaply online. It's a bit bigger, too!

There is a common misconception that high power LEDs cannot be strobed – turned on and off quickly – for a very similar reason that an incandescent bulb cannot be strobed.

Incandescent lamps have a high thermal inertia – their lamp filaments don't have a chance to cool down enough after each "flash".

So even though the current through a filament may be switched on and off rapidly, the filament temperature responds much more slowly; very slowly, in fact.

LEDs don't have the inertia of filaments. White LEDs are typically based on blue LEDs with an accompanying phosphor which produces the white light. And that is where the misconception arises.

Phosphors in fluorescent tubes do have inertia – certainly quite a lot of it. So when you switch a fluorescent light off, it takes a significant amount of time before the phosphor stops emitting light.

However, the phosphor in white LEDs does not emit light by phosphorescence; it works by a process called scintillation.

That means that there is no light persistence after each flash.

In fact, our tests demonstrate that these very bright LED floodlights can be flashed very rapidly indeed, up to 10kHz or more is easily done.

However, for a party strobe-light the flashing is not rapid at all, up to only about 18 flashes per second.

The previous Party Strobe was based on a LED floodlight which had no internal power supply and so it did have one major disadvantage – a separate box containing a beefy mains transformer.

It was intended to power

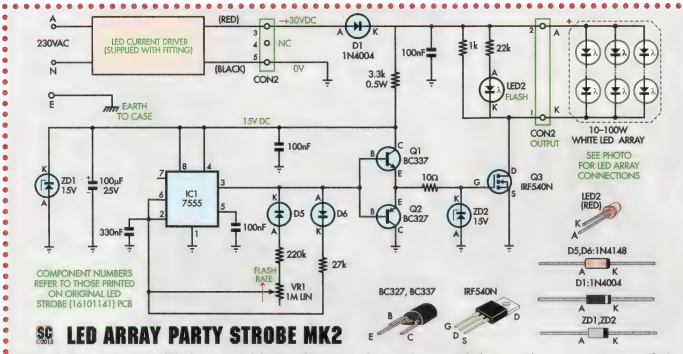


Fig.1: the circuit is a simplified version of that used in our earlier strobe – mainly because the mains power supply is already supplied fitted to the floodlight. We've also done away with provision for controlling a hot wire cutter.

LED floodlights ranging in power from 10W to 100W.

Our new Party Strobe is based on a 230VAC LED floodlight, sold in large numbers via the internet with ratings of 10W, 20W, 30W, 50W or 100W. The mains powered LED Driver is supplied already fitted and wired inside the case.

All are quite similar in presentation with their overall size increasing according to their rating.

The one featured in this article is rated at 30W but you could use any rating from 10W to 100W. However, we think 30W is probably enough.

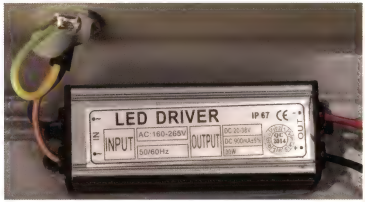
230VAC LED current driver

Not only is the construction of all these LED floodlights similar, their internal circuitry is much the same, comprising a switchmode current driver module rated for inputs of between 160 to 265VAC, or thereabouts. The current driver module is housed in a rectangular metal housing with plastic end pieces and it is typically held in place in the rear casing of the LED floodlight with silicone sealant.

The output voltage of these current driver modules is typically around 30 -36V DC and in the example we are using here, the current rating is 900mA.

And how are we flashing it? We are using the same switching module with only slight changes to the original LED Strobe circuit and this can be seen in the diagram of Fig.1.

The LED driver output of about 30V DC is fed via diode D1 is fed directly to the anodes of the 10W to 100W white LED array and also via a 3.3kΩ 0.5W



Above is the LED driver mounted inside the case (held in place by silicone sealant [which is quite OK]). The mains input lead is secured with a captive gland but the earth connection is not up to par. We will refit this to the proper standard. At right is the rear view. As mentioned in the text, we should have fitted the pot much further forward so it didn't foul the mounting bracket. Speaking of which, we had previously cut this to suit our location – it's normally a single "U" shape.

Commercial Strobes

We are aware that you can purchase ready-built LED strobes online, for not much more than the cost of a LED floodlight. But we're not convinced that the commercial models are as good as ours!

You can also buy a variety of LED arrays, either fitted to a floodlight housing (as ours was here) or loose. "Naked" LED arrays are commonly available in 10W, 20W, 50W, 70W and 100W ratings at quite attractive prices (100W LED arrays, for example, are less than $10.00 each!).

Incidentally, Xenon-tube strobes are still available. But we've seen some pretty extravagant claims of Xenon strobes power – for example, 1500W in one case! Now when you consider that the majority of Xenon tubes we used to use in DIY strobes were usually rated at 5W (actually 5 joules, or 5 watt-seconds) 1500W or even 1000W would seem to be a *bit* over the top. It's not dissimilar to a 5W RMS audio amplifier being advertised as 1000W PMPO. In those immortal words from "The Castle" . . . *they're dreamin!*

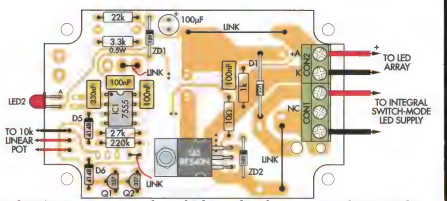
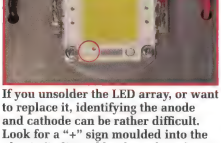


Fig.2, the PCB component overlay, which matches the same-size photo at right. This is the same PCB as used in the January 2014 Party Strobe but the circuit it simpler, as evidenced by the number of empty holes. Note also the four links required. Only the red and orange wires to the pot are actually required but we had a length of 3-wire cut from a ribbon cable so used it!

resistor to a 15V zener diode, ZD1. This provides a 15V DC supply rail to a 7555 timer (IC1) and transistors Q1 & Q2.

IC1 is connected so that it repeated charges and discharges the 330nF capacitor at pins 2 & 6 via diodes D5 & D6 from its pin 3 output.

The two diodes provide different charge and discharge times because of the different series resistances. For example, the charging path is via D6, and the 27kΩ resistor while the discharge path is via D5, the 220kΩ resistor and the 1MΩ potentiometer which is wired as a variable resistor (rheostat).



If you unsolder the LED array, or want to replace it, identifying the anode and cathode can be rather difficult. Look for a "+" sign moulded into the plastic (indicated by the red circle above). Contrarily, this is closest to the – terminal or cathode (see red and black wires). Never operate the LED array without it being secured to a heatsink.

The result is a fixed flash duration of 8ms (milliseconds) and a flash rate which can be varied from about three flashes per second up to about 15 fps. The flash rate is a compromise between apparent brightness and the "freeze motion" effect which is the whole point of a strobe.

The variable pulse train from pin 3 of IC1 is fed to the complementary transistors Q1 & Q2 and these buffer the output to provide cleaner switching of the following N-channel Mosfet Q3, an IRF540N and this is connected to the cathodes of the LED array to provide the rapid switching.

Since the average current is only around 1A maximum for a 100W LED array, no heatsink is required is required for the Mosfet.

A 1kΩ resistor is connected across the LED array to damp high frequency artefacts from the LED current driver. At same time, red LED fed by a 22kΩ resistor provide a visible indication that the circuit is working if the LED array is not actually connected or cannot be seen.

Obviously, this LED will not be visible once the switching PCB is housed inside the casing of the LED floodlight.

Note that the LED driver does not appear to be "troubled" by having its current output interrupted by this switching process. In fact, its output voltage will tend to rise to about 40V at low flash rates but then it simply shuts off intermittently to limit the output voltage to a safe level.

Construction

Like the earlier party strobe, this one is constructed inside a LED floodlight fitting. Unlike the earlier model, though, it is wholly self-contained because the floodlight is designed to operate of AC power (160-265V) through its tiny switch-mode supply module already fitted inside.

Believe it or not, mains-powered LED floodlights are not significantly more expensive than their 12V counterparts which we used last time. We obtained ours online for about $30.00 but prices do vary significantly so shop around!

The PCB is also mounted inside the fitting – but where the supply module is mounted inside the "lid", we secured the new PCB inside the body of the fitting, so that when the two halves are brought together, the new PCB clears the supply module. There is not a huge amount of space to spare – but there is enough.

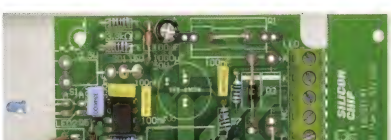
We're getting a bit ahead of ourselves but we used double-sided thick foam pads to secure the PCB to the case. These have several advantages, not the least of which is that they don't require any drilling and also act as insulators between the bottom side of the PCB and the metal case.

Double-sided foam pads are commonly available at stationery stores, office suppliers and newsagents.

Assembling the PCB

This is quite straightforward using the PCB designed for the original strobe (16101141), with the obvious difference that there are several component positions left unfilled and some components are slightly different to the original.

We have retained the component identification numbers from the silkscreen PCB overlay on the original



Due to its earlier multi-use format, the PCB had an end which could be cut off – shown above at the right end (but cut off in the overlay at left). It's up to you. As mentioned in the text, the LED is redundant once the case is closed – but it saves your eyes from the *REALLY BRIGHT* LED array while testing!

PCB to avoid confusion; there will obviously be "gaps" in the component numbering (eg, there is a D1, D5 and D6 but no D2, D3 or D4).

Simply follow the new component, noting which components are left out and which are replaced by a wire link.

Start with the lowest-profile components first, ie the resistors and small capacitors.

Follow these with the diodes and Zener diodes, taking care not to either mix them up nor get them around the wrong way.

Next are the LED and transistors (again, the BC327 and BC337 appear identical so watch their position).

Strictly speaking, the "flash" LED (LED 2; there is no LED 1) is not really required because when the unit is complete, it will be hidden inside the case.

However, we left it in situ because, for the sake of a few cents, it meant we could confirm proper operation without having to connect the blindingly bright LED array until we had to!

Next, bend the leads of the MOSFET down 90° in the appropriate place so it can mount flat on the PCB with its screw hole aligned with the hole in the PCB.

Many people find it easiest to temporarily screw the MOSFET to the PCB, grip the leads in the right place with a pair of fine pliers, remove the screw while still holding the leads with pliers and then bend them down along the edge of the pliers.

Now, snap together the two-way and three-way terminal blocks and solder them in position as a five-way, with the access facing towards the outer edge of the PCB.

Only four terminals are used; position number four is not connected.

The last component to mount is the 7555 timer IC – make sure its notch goes in the same orientation as the graphic on the screen overlay. Whether you use an IC socket is entirely up to you (but if you do, make sure its orientation is the same).

Mounting the speed pot

Unlike the earlier strobe, the speed pot is mounted external to the board via a short length of ribbon cable. While only two wires are required (shown in red and orange on the overlay diagram) we wired all three terminals.

Make the ribbon cable (and indeed the connections to the LED array and the switch-mode supply long enough to be able to open the two halves of the case to work on. We found that we needed to lengthen some of the cables with short lengths of the same colour hookup wire, with the soldered joints covered by heatshrink insulation.

With 20/20 hindsight, we wouldn't have mounted the pot in the middle of

Parts list – LED Party Strobe Mk II

1 double-sided PCB, coded 16101141, 95 x 49.5mm (First used January 2014)
1 10 to 100W LED floodlight, mains operated (see text)
1 2-way terminal block (CON1)#
1 3-way terminal block (CON2)# (combine to make 1 x 5-way)
1 short length tinned copper wire
1 knob to suit VR1
1 3-pin mains plug
1 M3 6mm machine screw and nut
4 double-sided foam adhesive pads
1 100mm length 3-way (or 2-way) rainbow cable
Short lengths heatshrink tube
Short lengths red and black hookup wire

Semiconductors
1 7555 CMOS timer (IC1)
1 BC337 NPN transistor (Q1)
1 BC327 PNP transistor (Q2)
1 IRF540N Mosfet (Q3)
1 3mm red LED (LED2)
1 1N4004 1A diode (D1)
2 1N4148 signal diodes (D5,D6)
2 15V 1W Zener diodes (ZD1,ZD2)

Capacitors
1 100µF 25V electrolytic
1 330nF MKT *(code 334, 330n or 0.33µF)*
3 100nF MKT *(code 104, 100n or 0.1µF)*

Resistors (0.25W, 1% unless otherwise stated)
1 220kΩ *(code red red yellow brown or red red black orange brown)*
1 27kΩ *(code red purple orange brown or red purple black red brown)*
1 22kΩ *(code red red orange brown or red red black red brown)*
2 3.3kΩ 0.5W *(code orange orange red brown or orange orange black brown brown)*
1 1kΩ *(code brown black red brown or brown black black brown brown)*
1 10Ω *(code brown black black brown or brown black black gold brown)*
1 1MΩ linear 9mm potentiometer (VR1)

the case because it restricts the travel of the mounting bracket.

Fortunately, this didn't matter too much in our case but if you need to be able to swing that bracket over a wide arc to aim the strobe where you want it, mount the pot as far up the case as you can.

Aaagh – no power plug!

Probably because the floodlight is sold to all corners of the earth (it does have a 160-265V supply), there is no power plug fitted.

But perhaps worse, the mains lead is only about 200mm long, so you'll either need to fit a mains plug and use it with an extension cord, or fit a mains junction box to the short cable.

Whatever you choose, ensure that your mains wiring is safe and triple checked before use.

Testing it

After checking your component placement and soldering, connect the assembled PCB to the switch-mode supply module (watch the polarity!) without yet connecting the LED array.

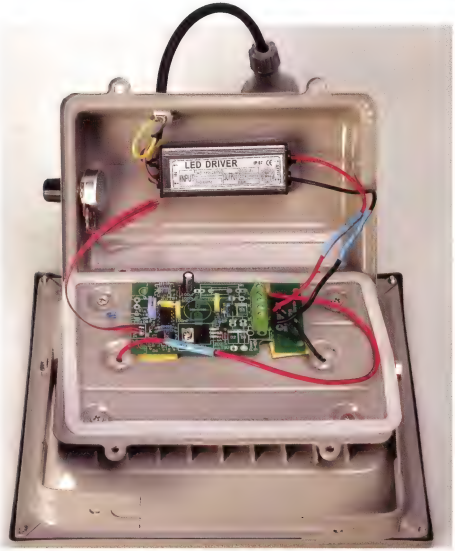
Connect the mains plug and switch power on. You should find that the "flash" LED does just that – flash – with timing (ie, flash rate) adjustable via the potentiometer.

If it doesn't, you obviously have a component error or bad solder joint. Check the voltage across the power input terminals (3 and 5; remember 4 has no connection) where you should read somewhere around 30V DC.

If this is OK, check the voltage across pins 1 and 8 of the IC – that should be very close to 15VDC.

If this is OK, the only possibility is (again) a wrongly-placed component or a bad solder joint. Make sure you haven't mixed up the Zener diodes and the signal diodes (D5/D6), or that you haven't swapped the two transistors (Q1 and Q2).

If you find that the LED flash rate is highest when the pot is at minimum, simply reverse the connections to the pot (the ones shown in red and orange).



Here's the almost-completed Party Strobe, immediately before we fixed that dodgy earth termination and then joined the two halves of the case. You can see the four adhesive foam pads we used to secure the new PCB to the case, along with the lengths of heatshrink cable over wire joins to prevent shorts. Make sure you have the neoprene washer in situ before screwing together AND that none of your internal wiring is poking out! Incidentally, we had to fit the three-pin mains plug seen at the top of the photo above – the floodlight is supplied with only a very short mains cable.

Connect the LED array

If everything checks out, unplug it and wait for the Flash LED to stop flashing. Then connect the wires to the LED array (watch the polarity!).

Turn the reflector away from your eyes and briefly plug the power in again. You should be rewarded with some very bright flashes – again, adjustable via the flash rate pot.

Screw the case together, ensuring that the gasket is in place and that none of the internal wires have managed to spill outside the case. And that's it: your Party Strobe is now complete.

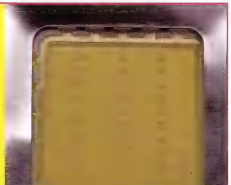
Finally, throw a party! SC

WATTS THE LED ARRAY POWER?

There is no marking on the LED Arrays to tell you what the power is. But this one is a 30W array; the one overleaf is a 100W type. How do we know?

Simple: count the number of vertical rows. Each row accounts for 10W; here there are 3 rows so it's a 30 watter. The one overleaf has 10 rows, so it is a 100W type.

As mentioned earlier, don't be tempted to operate these without a heatsink (they don't need insulation) and if you stare straight into them, well, your mother told you . . .



SERVICEMAN'S LOG

My love/hate relationship with cars

Dave Thompson*

One of the advantages of being an electronics/computer technician is that I can tackle basic electrical problems in my MG-F sports car and my mini-van. I cannot say that I always enjoy tackling such problems though.

Items Covered This Month

- Tracking down faults in my van and MG-F sports car
- The intermittent engine immobiliser
- Bauhn 99cm LCD TV

*Dave Thompson runs PC Anytime in Christchurch, NZ.
Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz

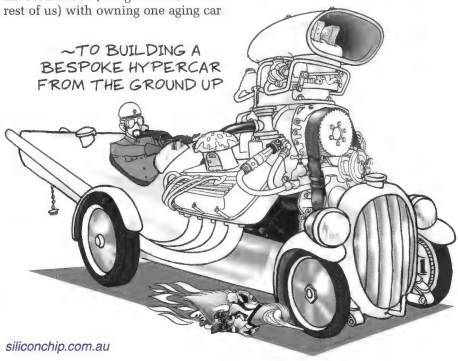
It's no secret to my friends and family that I like cars. If I had the bottomless resources of a dot-com gazillionaire, I'd have dozens of selected 4-wheel collectibles stored in an aircraft-hangar-sized garage, with a living space off to one side. On the other side would be a large workshop complete with a 4-point lift and enough top-of-the-line tools and machinery to enable me to do anything from changing wiper blades to building a bespoke hyper-car from the ground up.

And I'm not alone; many other people share my automotive dreams to varying degrees and indeed there are many out there in real life who own such hangar/garage/workshops and have the income to support their passion.

Being a humble serviceman, I obviously don't have that kind of coin and have to make do (along with 99% of the rest of us) with owning one aging car at a time, although I also have a business van. Others are fortunate enough to own a daily-driver and maybe a project (that may or may not ever be finished) taking up half the garage.

One of my bucket-list aims is to build a car and I almost got there awhile back, until the earthquakes and their aftermath put the brakes on that particular goal. One day though, I hope to remedy that situation and complete a bespoke car build.

On the other hand, it may surprise you to know that tracking down faults in cars is not one of my favourite pastimes. Despite not carrying any excess weight, I'm finding that, as I get older, I'm less able to shoehorn myself into the tight spaces that one often encounters when working on cars. What's more, I'm becoming less and less enamoured with the challenge of doing so.



Of course, it helps immensely if one is a contortionist but I'm not and never have been. And as advancing age adds to my lack of flexibility, the thought of threading myself into those tight positions holds much less allure than it did 20 years ago.

This access issue can sometimes make an otherwise enjoyable pastime very trying. The vast majority of cars these days are partially assembled by robots and some seem to be deliberately designed to make even basic maintenance prohibitive. While all marques suffer from this issue, older British-made cars were particularly bad, with many components apparently added as afterthoughts. They often turned what should be a routine job into a marathon of removing rusted bolts, brittle fairings, apparently single-use plastic clips and other access-restricting obstacles.

Adding to the problems, many cars, regardless of age and country of origin, require special spanners or other dealer-only tools to do certain jobs. And that also puts the handbrake on enjoying DIY maintenance and repairs.

These days, just changing spark plugs can be an afternoon's work once you (a) figure out where they actually are in amongst the jumble of shrouds, "beautification" panels, plumbing, cabling and various accessories inside a modern engine-bay and (b) manage to remove all that stuff to gain access. And you can now pretty much throw

The intermittent engine immobiliser

A car that intermittently stalls in traffic is a real problem and tracking down such a fault can be a nightmare. A. C. of Claremont, Tasmania encountered one such problem in a Mitsubishi Magna but it was all due to some aftermarket equipment. Here's what happened . . .

My main set of wheels for the last 16 years has been a 1994 V6 Mitsubishi Magna TS wagon. As well as Australia, the Mitsubishi TR and TS series Magnas were also sold in Europe as the Sigma, and in Japan, NZ and the USA as the Diamante. They are all nominally the same vehicle but with slight cosmetic and mechanical changes.

Because it was the first vehicle I bought with my own money, I have always been quite attached to it. And despite it being thirstier than comparable V6 wagons, I have always felt it to be a good compromise in terms of size and power, whether it be driving around suburban streets, helping somebody move something bulky, towing a trailer-load of rubbish to the tip or cruising along highways.

About 13 years ago, it developed an annoying (and potentially dangerous) fault, whereby the engine would simply cut out for no apparent reason. For example, the car could be fine for weeks and then, seemingly at random while idling at the lights, the engine would simply stop. Turning the key would then immediately restart the engine and the car would then run flawlessly for several more weeks

On the other hand, if the engine tried to die while travelling at speed (>60km/h) the car would initially lurch as the engine cut out and then the car would in effect "roll-start" itself a fraction of a second later. This stalling problem always occurred when the engine was warm and was never accompanied by any coughing or spluttering.

A couple of trips to a local mechanic resulted in no real progress in resolving the fault. Among other things, the injectors were cleaned, the fuel rails flushed, the idle step controller replaced, the fuel filter replaced, the distributor checked and various sensors tested – all to no avail. No error codes could be "pulled" from the Engine Control Unit (ECU) and no tell-tale warning lights illuminated on the dashboard when a stall occurred, making diagnosis very difficult.

After a third trip to the mechanic, the fault appeared to disappear and was declared "cured". The car then gave 11 years of uninterrupted service

Unfortunately, around 18 months ago, the fault reared its ugly head again. To make matters worse, the problem appeared to be occurring more frequently than before, with at least one engine stall per trip. This was now a real problem, because my employment circumstances meant that I had to use the car to and from the office so I needed it to be reliable.

I had a new mechanic by this stage and after telling him of the problems I had 11 years ago, he surmised that the problem was electrical rather than mechanical. However, after thoroughly checking the car's electrical systems, he couldn't find any faults.

In desperation I started hunting online for solutions. Several internet pages were unearthed from people who described a similar-sounding problem, but none of the descriptions quite matched the fault I was experiencing – namely, sudden engine runabout MG-F. The van is one of those tiny Japanese models known over there as a "Kei" (pronounced "K") car – a class of vehicle that's under a certain size, weight and engine displacement. The MG-F, on the other hand, is one of the last British-made MGs from their Abingdon works. Both represent their respective country of origin and their design and manufacturing processes quite well.

The van is very technologically-advanced and literally runs on the smell of an oily-rag due to the tiny-but-clever DOHC EFI engine and next-to-nothing body weight. However, one gets the impression that a good sneeze would blow the doors off or at least distort the wafer-thin metal body-work. I would not like to have a collision in this van with anything harder than a feather pillow but as long as I steer clear of solid objects, it's a very good vehicle.

Its recent problems arose when weird electrical things started happen-

away traditional DIY motor-mechanic tools such as timing lamps, dwell meters and compression gauges because they are either obsolete or there is no room left to use such things.

Sure, you can replace these old-fashioned aids with OBD (on-board diagnostic) readers and other fancy diagnostics tools but many of these are either not available to the general public or hellishly expensive if they are. And that often means a trip to a local dealer (with their high service costs) if you want even the simplest of jobs carried out on a modern car engine or computer-management system.

Don't get me wrong; I used to love whiling away a pleasant weekend afternoon tinkering with my cars in years gone by and I still do some of the more accessible jobs on my present car. However, my point is that most simple DIY tasks have now been virtually rendered impossible for the home mechanic due to the modern practice of computerising everything from the ignition timing to the interior-light delay and even when it comes to monitoring tyre pressures.

That means that unless you are particularly knowledgeable regarding your car's various systems and have some seriously tricked-out tools, the prospect of doing any useful servicing is quite daunting. It's certainly nowhere near as enjoyable as pottering around with the timing lamps and dwell meters of yesterday on engines that could be accessed without removing half the engine bay and which could be fixed with just a shifter (or "crescent" in Kiwispeak), a screwdriver and a can of CRC.

What's behind the rant?

The reason for the above mini-rant can be put down to a couple of jobs I recently attempted to tackle on two very different vehicles, one of these being our business van and the other

gine cut-out and the ability to immediately restart it.

Eventually, a glimmer of hope emerged from someone who suggested checking the immobiliser. I knew that my car had been fitted with an aftermarket immobiliser when I purchased it 16 years previously, so this was worth exploring as a last resort. If I couldn't track the problem down, I would have to admit defeat, cut my losses and trade the car in for a newer alternative.

After removing the driver's side foot-well covers, I eventually found the immobiliser control box hidden under the steering column. The installation had obviousky been quite hastily executed by the original installer, with the control box strapped in with cable ties and black electrical tape. On a whim I started the car and while it was idling, reached under the steering column and gave the plastic control box a squeeze with my hands. Sure enough the engine died straight away.

Feeling confident by now that I was finally on to something, I pulled out the connectors from the box and extracted it from under the dashboard to have a closer look at it. When I removed the cover, I found that three relays were mounted on the main PCB – one to operate the horn if the alarm was triggered, a second one to flash the indicators when arming/disarming the unit, and a third to interrupt the ignition circuit to prevent the engine from firing if the immobiliser isn't first disarmed.

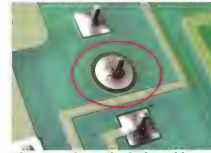
It was near this last relay that the problem was apparent. There was a small area of discolouration on the PCB adjacent to the relay, clearly indicating that something had been getting hot (see photo).

Flipping the board over revealed a dry solder joint under this third relay and this can be clearly seen in the second photo. At long last there was an explanation for the engine stalling issue with the car – the solder joint on the PCB was obviously bad enough to interrupt the ignition circuit and temporarily immobilise the engine.

The fact that the problem occurred only after the engine had warmed up was easily explained as well. The current flowing through the faulty joint caused it to gradually heat up and expand, making it more likely that the engine stalling problems occurred after the first 15 minutes or so of driving.

Having found the problem, the rest was easy – the faulty PCB joint was reflowed with solder and the immobiliser refitted to the car (more securely than before). The old Magna has now been completely fault-free for the last 12 months and appears to be running as good as new.

The discoloured track (circled) on the top of the PCB was the first indication that something was wrong with the relay connections.



This view shows the faulty solder joint. The solder not only has a grainy appearance but has failed to adhere properly to the relay pin.

ing. For example, one day you'd get in and the digital clock on the dash would be dark whereas the following day it would be as bright as normal. And sometimes the idiot lights indicating what gear the automatic transmission was in wouldn't light up, which meant you'd have to be careful with the gear selection. On other days though, the lights worked as expected, so there was obviously something intermittent in the electrical system somewhere.

My first stop was the fusebox and relay clusters. Automotive relays are often just plugged into sockets without any form of retaining mechanism and like fuses, can vibrate loose over time. Their contacts can also oxidise due to the condensation that's frequently caused by the repetitive heating and cooling cycles of a car's engine.

What's more, given that the sockets are often made from the same flimsy plastic used elsewhere in cars built to a price, they can break down and become brittle or distort out of shape. So it's well worth checking them out to ensure that an intermittent fault isn't being caused by something as simple as a dirty contact or loose component.

Now while the minor problems I was having with the van were hardly show-stoppers, my concern was that they were an indication that maintenance was required before things got worse and something really embarrassing (or dangerous) happened. That "something" could be the engine dying just as I pulled out into the middle of the biggest intersection in town during the morning rush. Grumpy,

...DUE TO THE INEVITABLE SPAM THAT RESULTS FROM SHARING YOUR ADDRESS

sleep-deprived motorists universally dislike having their morning routines interrupted in any way, especially if it means they miss the current traffic lights cycle. And since the van is emblazoned with my company name and phone numbers, it's just asking for some unpleasant feedback.

Indeed, drivers here in Christchurch are not afraid of dialling the mobile number displayed on a vehicle and advising the person who answers that they are a socially-undeveloped individual of dubious parentage and that they should go forth and multiply as soon as possible!

The fear of road-rage aside, what prompted me to take this a bit more seriously was the fact that, out of the blue, the passenger door's central-locking mechanism had also now decided to stop working. As anyone with central-locking will tell you, locking doors manually soon becomes a lost habit. In my case, I returned to the van and found that the passenger's door was unlocked on several occasions before I realised the central locking wasn't doing its job.

That was the final straw. Coupled with the other electrical gremlins, this finally demanded further investigation.

Initially, I hoped that cleaning the relay contacts with a squirt of Electra-Clean and then reseating the relays in their sockets would make the gremlins disappear. And indeed, that fixed the transmission indicator lights problem but it didn't fix the clock which was a minor issue. More importantly, it didn't fix the central locking problem.

Tracking down the various fuses, relays and other components wasn't an issue because the Japanese designers had thoughtfully placed them so that they could be easily accessed without removing half the body panels. And thanks to Google and the internet, I didn't even need to go out and source a service manual because several had been uploaded to the web by considerate users.

Unfortunately, the sites hosting the manuals required me to submit my email address before I could download anything (something I dislike doing these days due to the inevitable spam that results from sharing one's address) but it was a small price to pay to get my hands on the information I needed. Besides, I have a couple of junk email addresses I use on these occasions and I only check their "inboxes" when I have to, in order to retrieve downloaded files and other information.

In fact, it's a smart move these days to have a second email address as it keeps your primary email address out of the hands of the spammers and marketers (Gmail offers a good, free service in this regard).

Anyway, I digress; my quick fix hadn't succeeded in getting the central-locking working properly but at least I now knew that the fuse and relay holders were in good condition. My next logical step then was to check the wiring loom between the door and the chassis for any obvious signs of chafing or breakage (another common problem area). This all proved OK as far as I could tell, so there was nothing for it but to remove the door card and eyeball what was going on.

With central locking, if the key is turned in the driver's door lock or if that door's locking peg is pulled up and down, it should operate all the other door locks in unison. And in fact it seemed that the mechanism was trying to operate the passenger's door lock because the peg moved slightly every time the driver's door lock was toggled from locked to unlocked and back again.

Thinking that something might be jamming or obstructing the mechanism, I tried alternately pushing and pulling on the lock button while operating the driver's door lock to see if that would assist it operate. It didn't help but on the other hand, the passenger side's pushbutton and keylock mechanisms actually operated quite easily when it came to locking and unlocking the door. And that meant that it was probably the actuator itself that was failing to move the lock mechanism.

That wasn't good news because it meant trying to source another actuator unit and given this brand's track record with spare parts, it would likely cost more than the car was worth (well, almost). Of course, I could try to source one secondhand but since this van is a bit of an oddball import on the roads here, the likelihood of another one sitting in a breaker's yard somewhere with good working parts was pretty slim.

Given those facts, all I could do now was strip the door down and see if I could see anything obvious once I exposed the mechanism. The door-handle and armrest came off easily, with just a few large PK-style screws holding things together. Then, using a wide strip of hard plastic, I worked my way around the door-card and gently persuaded the clips to let go.

Once I got them all free and had removed the card, I could see that someone before me had done the usual cowboy thing and had used a screwdriver to remove the clips. However, he'd pulled half the clips out of the door-

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? It doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

card instead of the door frame and that meant I'd have to repair those before I put it all back together.

Once the card was off, I could see the actuator and electric window assemblies riveted into the door frame. This is another common method employed by manufacturers these days; everything is riveted in, meaning removing and replacing these units requires a lot more tools than a simple screwdriver.

Regardless, the central-locking actuator was a sealed unit and both it and the wiring going into it looked brand new, so it seemed the most likely reason it was struggling was because the solenoid had gone weak with age and could no longer toggle the lock mechanism. There was nothing I could do other than squirt some silicone and graphite-based lubricants into every likely spot in the system. I then glued the door clips back onto the door card with epoxy resin and when dry, put it all back together.

Unfortunately, lubricating the system didn't solve the locking problem. Fortunately, it isn't a mission-critical problem and it is a work van so I'll just have to get back into the habit of checking the door lock manually. If I get the opportunity to replace that actuator I will but I'm not going out of my way to replace it.

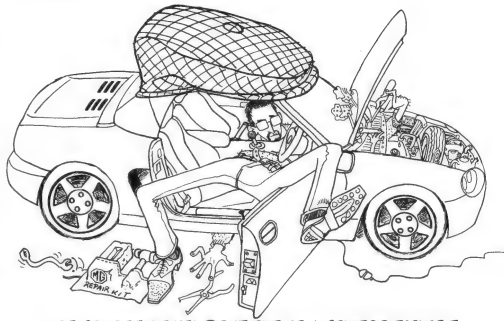
Fixing my MG-F

My British-built MG-F car is very basic compared to the Japanese-made van. Its problem involved a non-operational electric window on the driver's side.

Now while the electric windows on the van operate smoothly and quietly, the driver's side window on the MG has a tendency to grunt and groan whenever it's activated. At least, it did until one day the window stalled halfway down and then wouldn't move either way. I could toggle the switch and hear the window try to move and see an accompanying shudder, so it seemed that everything was OK electrically but something was preventing it from moving.

Once again, taking off the door card was simplicity itself and once again half the clips stayed behind because someone had previously "had a go". Why people can't use the right tool for this job is beyond me. It meant that, at the very least, I was going to be up for more door-card repairs.

Once the door-card had been removed and the clear plastic lining peeled back (the previous guy had simply used some silicone sealer to glue it in place and had made a very messy job of it), I could see the scissor actuator inside the door. I could also see that a small screw had worked its way loose from somewhere and had jammed the mechanism, so there was no way it was going to move.



~OF COURSE IT HELPS IF ONE IS A CONTORTIONIST

It was easy enough to remove but for the life of me I couldn't find where the screw had come from, even after using a mirror and a good torch to probe every nook and cranny. In the end, I simply lubricated the mechanism and after testing the window to see that it now freely moved up and down, scraped off the old silicone, replaced the plastic lining, repaired the door-card and reassembled everything.

The window then needed a slight adjustment to get it to seat properly into the seals and it is now still working fine several weeks later. However, I now often wonder just where that screw came from and what it was actually holding together!

Bauhn 99cm LCD TV

LCD TVs that are out of warranty are now often thrown away if they develop a fault. A. P. of Briar Hill, Victoria recently managed to save one such set from landfill but it took a lot of perseverance. Here's what happened . . .

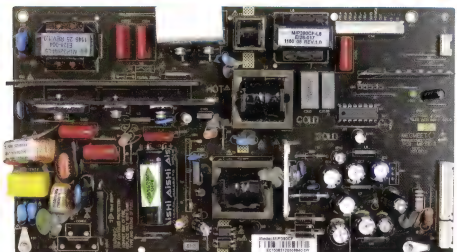
I hate seeing an expensive piece of gear junked simply because a repair is deemed impossible or uneconomic. Unfortunately, it's a trend that's unlikely to be reversed but one thing that has changed for the better is the internet. There's now a wealth of information out there and sometimes a bit of searching can turn up vital information that allows an item to be repaired.

As an example, my daughter recently asked me to have a look at her dead Bauhn 99cm LCD TV. She remembered having paid nearly $400 for it a couple of years ago and was dismayed when it failed just two months after the warranty had expired. Undeterred, she had made a warranty claim but the answer was a polite refusal.

I commiserated, of course, but secretly thought that this would be an excuse to get it into the workshop and have a look inside. Ever since I was four years old, I've struggled to resist pulling things apart just to see the works. This was my first chance to look inside a large flat-panel TV and as it was outside warranty, there was little to lose by giving it a go. After all, there's always the chance that it might be a relatively simple repair.

When I got it home, I cleared my workbench and laid the set face-down on a large towel. I then removed over a dozen screws, lifted the back off and took a look inside. With its multitude of functions and inputs, I had expected it to be crammed full of electronics but to my surprise, it was mainly empty space.

Inside, there was just the LCD panel, two densely packed circuit boards with a combined area less than an A4 sheet of paper, and some ribbon cables. The board with the numerous electrolytic



This photo shows the switchmode power supply board for the Bauhn 99cm LCD TV. The CCFL inverter circuitry is at top right, with the two MDF5N50F Mosfet attached to a common heatsink just to the left of top centre. Note that the 3A fuse near the Mosfets has been removed from this board, as has the mains connector at bottom left.

capacitors, including one large 100µF 450V unit, was clearly a switchmode power supply. The other board with its range of external connectors, including the antenna socket, HDMI inputs and various other inputs/outputs, was clearly a processor board. Both boards appeared to be in good order, with nothing looking burnt or damaged.

I decided to remove the power board and check its electrolytics first. While none were showing any signs of distress, such as leaking electrolyte or bulging tops, I nevertheless checked the lot with my ESR tester. None tested faulty, so I then tested the larger diodes and resistors with a DMM but they all checked OK too. And so, with nothing obviously faulty, my hopes of a quick and easy repair were quickly beginning to fade.

Taking a closer look

It was time to take a closer look at the symptoms. There was no picture or sound when the TV was turned on, the only sign of life being the red standby LED on the front panel. This LED turned blue when the remote control was operated.

At this point, I decided to plug the set into an isolation transformer for safety and check the output voltages from the power supply board. Fortunately, the socket connections were labelled 5V, 12V & 24V and all proved to be spot on. To get a better idea of what was going on, I also connected a power meter at the plug and noted that the set drew about 5W in standby mode, rising to 15W when turned on.

I then disconnected the power and immediately felt the heatsink on the large processor chip. It was comfortably warm and that, together with the voltage checks, suggested that a good deal of the circuitry was probably working. However, I was no closer to pinpointing the source of the problem.

This seemed a good time to see if the internet might throw up some suggestions or perhaps a schematic. Not infrequently, a web search about a problem with a specific device will identify a fix, sometimes complete with videos showing how to undertake the repair. In this case though, various searches involving the brand and model number of the set produced nothing useful. At least, there were no indications that the problem was a common one with this particular TV.

After a bit more searching, I found a repair forum at http://www.badcaps.net/forum/ that provided a good explanation of how LCD TVs work and how to test for common problems. In many of these TVs, the backlighting is provided by tubular cold-cathode fluorescent lamps (CCFLs). These need to be driven by an inverter which provides a high AC voltage.

According to the website, these inverters are generally powered from a 24V source and faulty power supplies, faulty inverters and faulty lamps are not uncommon. It had crossed my mind that the backlighting might be the problem but I had initially dismissed it since there wasn't even a faint picture and nor was there any sound. However, I learned from the website that failures in one section can lead to other functions being automatically shut down.

Armed with this new information, I took a closer look at the power supply board to see if I could identify the CCFL inverter. Sure enough, a strip of components along one edge of the board included a number of transformers and cables that lead to the CCFLs. However, rather than being fed from the 24V supply, the inverter was fed directly from the aforementioned 100µF 450V capacitor. That meant that this capacitor was filtering both the main switchmode power supply and the CCFL inverter supply.

Push-pull Mosfets

The supply to the inverter came in via a 3A fuse and was fed to a pair of Mosfets connected in a push-pull configuration. I hadn't spotted the fuse before and I quickly discovered that it was blown and that both Mosfets were shorted.

The Mosfets were marked MDF5N50F and were from a manufacturer I hadn't heard of but a web search quickly produced a datasheet. Further searching showed that many manufacturers produced similar N-channel Mosfets with "5N50" in the device number and that these devices are nominally rated at 5A and 500V.

Initially, I hoped that I might be able to source identical Mosfets online but drew a blank. I then began looking for suitable substitutes but found that superficially similar devices can have markedly different parameters, particularly in regard to turn-on and turn-off speeds. The original Mosfets were relatively high speed devices.

After poring over a dozen or so datasheets, I finally settled on a device from a large US manufacturer. They cost around $1 each and I began placing an order but in the process discovered that postage and handling was in excess of $50, so I stopped! No way was I going to spend that sort of money without knowing whether the devices had failed of their own accord or been destroyed by something else.

Finally, after a lot of searching, I

found a very similar device with only slightly inferior switching speed. These were available at five for $12 including postage, so I placed an order. They arrived a few days later and I eagerly mounted them on the heatsink, soldered them in place and replaced the blown fuse.

When I turned the TV on, I was immediately rewarded with the menu screen. And so, feeling rather pleased with myself, I hastily put the back on, stood the set up, connected an antenna and turned it on. In TV mode, I got an excellent picture and sound but before I could trumpet my success, the screen went blank again.

I removed the back and it was immediately clear that the new Mosfets had short-circuited and the fuse had blown again. My triumph had lasted just five minutes.

That set me thinking: was it a design problem, was some other fault destroying the Mosfets or were the Mosfet specifications especially critical? As the TV had run for two years and the model didn't seem to have a bad reputation, I concluded that the design probably wasn't the issue. Furthermore, after drawing out the Mosfet gate driver circuitry, I couldn't identify anything that might account for the destruction.

It seemed that the Mosfet recovery time probably was a critical factor. In the push-pull configuration used here, any time period that both Mosfets were conducting simultaneously, however brief, would result in a potentially destructive discharge path for that 100µF capacitor which is charged to well over 300V.

Back to the internet

I went back to the internet to do some more research into how these inverters work and to find out which factors were critical. Interestingly, there are Wikipedia and other references to the evolution of the circuit designs specifically used to drive CCFLs in LCD TVs. The inverters can operate at some hundreds of kHz and Mosfet fabrication techniques have been refined to provide devices capable of operating in these applications.

At that point, I decided that I needed to obtain identical Mosfets to the originals rather than use substitutes. I needed to get them at a reasonable price though but I wasn't having any luck until I mentioned the problem to a friend who was born in Hong Kong and can read Chinese. He was able to source some from China at under $2 each including postage.

They arrived a week later and I duly fitted them and switched the set on. Sadly, my success was again short lived. After just five minutes, these new Mosfets also shorted and I was beginning to have some doubts about them. Were the replacements counterfeits or perhaps sub-standard?

When I looked closely at the case markings, the maker's logo and fonts used were definitely slightly different when compared to the originals. It wasn't conclusive proof but it was enough to raise my suspicions.

While I'd been waiting for the parts to arrive, I'd drawn a schematic for most of the inverter circuit and tested every single component. This involved removing some parts and cutting tracks where in-circuit testing wasn't possible. I could find nothing wrong. The only device I couldn't easily test was an SG3525AN chip and its associated surface-mount components that generated the waveforms to drive the inverter.

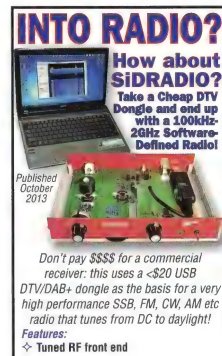
A web search turned up a datasheet and showed that the device was designed for this type of circuit. Interestingly, the chip featured "adjustable deadtime control" and this set me thinking that a problem in this area could leave both Mosfets turned on at the same time, leading to early destruction.

At that stage, having spent many hours without much success, I began to seriously think of tossing in the towel. And then, while contemplating defeat and staring at the power board, I noticed that an MIP390CF model number was printed on the PCB in three separate locations. Out of curiosity, I did an internet search on this number and got a series of hits.

It turned out that this board was used in some LCD TVs carrying a different brandname in the US. What's more, there were a number of eBay sellers willing to ship a board to Australia for less than $A50 including postage.

The available boards had either been refurbished or recovered from TVs that had suffered mechanical damage. What's more, the photos showed boards that appeared to be virtually identical to the one I had, except that the mains lead connector was a smaller 2-pin unit on the US board.

After some thought, I decided on one last toss of the dice and ordered a board from the cheapest seller. When it arrived, I inspected it carefully to ensure it was designed to work at 230VAC as well as the 110VAC used in the US. Once that had been confirmed, I swapped the mains connector and mounted the board in position. I then turned the set on and up came a picture but the next five minutes were tense. It continued working and after half an hour, I declared the problem cured.



Don't pay $$$$ for a commercial receiver: this uses a <$20 USB DTV/DAB+ dongle as the basis for a very high performance SSB, FM, CW, AM etc radio that tunes from DC to daylight!

Features:

- Tuned RF front end
- Up-converter inbuilt
- Powered from PC via USB cable
- Single PCB construction

Lots of follow-up articles, too!

Want to know more? Search for "sidradio" at siliconchip.com.au/project/sidradio

PCBs & Micros available from On-Line Shop

What cased them to fail?

So what was causing premature failure of the Mosfets? I think it is most likely that there was a problem with the waveforms driving the Mosfet gates but I can't be certain. I was initially tempted to investigate further by comparing the waveforms from both boards but eventually decided that this carried too big a risk of damage while trying to make connections to the closely-packed components.

In the end, my daughter was very pleased to have her TV working again, albeit after several weeks of waiting. And she doesn't care in the least that the source of the original problem isn't fully known. SC

Move over, Austin Powers! You might have had an actor Mini-Me in the movies but I have one of my own, printed in 3D at my local Officeworks store! And he looks just like me – just a little smaller!

By Kevin Poulter and Ross Tester

Here is Me – and Here is Mini-Me!

3D printing is not exactly new – the technique of printing (or sometimes sintering) layer-by-layer to produce objects in the X, Y and Z dimension has been around for at least 20 years (see SILICON CHIP, September 1996).

It's been used to "print" everything from impossible-to-obtain replacement parts for vintage radios through to components required in space . . . and everything in between.

It is increasingly popular in industry, business, medicine and even hobbies.

You can even look up various websites for the code required for that widget you really want to print.

And you can also use multi-camera exposures and appropriate software to reproduce, well, whatever you like.

Officeworks and Mini-Me

It's this latter development that has prompted some rather interesting product offerings! Officeworks, best known as a supplier of stationery, office furniture and computer equipment, has recently expanded the Print Shop (first of all at their Russell St, Melbourne outlet) to include full-size scanning of quite large items, then printing them in 3D.

Their 3D facility aims to unlock 3D printing potential, allowing people to touch, play and learn about 3D printing and how they can use it in their everyday lives.

Following Officeworks' launch of Australia's first mass-market 3D printer last year, their 3D Experience Centre signifies further

Step into the Officeworks scanning booth and 144 cameras produce a 3D file. After processing, it takes about two weeks for your Mini-Me to be produced.

A range of figurines produced by 3D printing from live "models" by Officeworks at their Russell St, Melbourne outlet. Want to be immortal?

expansion into this technology, giving customers access to a range of 3D products and services.

You can either submit your own scan file, or use Officework's scanning booth. Scanning of most objects takes between 15 and 30 minutes to complete and costs $10 for small objects, $15 for medium objects and $20 for large objects.

Scan yourself!

If the scanned item happens to be . . . you . . . then they can print out a small version of you, accurate in detail and proportion. It is, in fact, a Mini-Me.

A customer only needs to stand for about five seconds in the Officeworks "people" scanning booth, as 144 individual cameras are fired at exactly the same time.

The file is retouched, processed to a CAD file and sent to an off-premises printer, then returned as a 3D statuette about 2 weeks later.

Providing the backend support is an Australian 3D printing company called Keech 3D.

The price depends on the size and also the materials used to print but ranges from $39 (80mm high, in PLA plastic) to $579 for the largest size available (240mm high in Resin).

3D print materials, ranging from cheapest to most expensive, include powder, paper, PLA plastic, ABS plastic and resin.

Being the most durable, resin is the most expensive but it can only be printed in a single colour.

While the Mini-Me has good detail (and can include objects like a golf club or other items you'd associate with the person) there are some disadvantages:

The multiple cameras appear to output in a slightly spherical result (like a wide-angle lens), making a larger person's waistline look bigger. And it must be said, the cheaper 3D Mini-Me versions are more fragile.

Most 3D images are printed in one colour but it is possible to print separate parts using different materials and/or colours. A separate 3D model file is required for each piece.

However, 3D print files supplied in .OJB format (Wavefront Technologies Object File) or .WRL (Virtual Reality Modelling Language) can be printed in full colour.

An alternative is to print in a neutral colour and paint the model to suit.

Officeworks are using the Russell St 3D scanning and printing centre as a test site for possible expansion into their other stores throughout Australia.

Overseas experience

In Europe, 3D print cafes have already become quite popular – including Mini-Me-capable printers.

It's a case of print your coffee cup, then drink from it!

3D Cafes are not only providing the facilities for printing, they're also providing the expertise and training for customers to do their own printing.

At DimensionAlley in Berlin, for example, it's common for customers to make figurines of themselves for giving to friends and relatives!

Most 3D print centres use relatively low cost hobby-type equipment. Print costs are commensurately low, about $10-$15 per half hour being about the going rate.

They're also popular around universities, where students don't just create visuals of their projects any more – they create models, detailed in every respect. SC

Vintage Radio

By Associate Professor Graham Parslow

The 1955 Fleetwood 4-Valve Model 1003

The Fleetwood logo depicts a sailing ship at the top and an oak tree in the bottom half to reflect the town's maritime past.

The Fleetwood Model 1003 is a 4-valve set that was manufactured at Philips' Hendon plant in South Australia during the 1950s. It's a relatively simple design based on 9-pin valves and has quite good performance.

FLEETWOOD is a coastal town in Lancashire, England, north of Blackpool and like Blackpool is also a resort town. And unusually for England, Fleetwood is a planned town that was laid out in 1835.

The town's largest and most prominent single employer is currently the manufacturer of the menthol lozenge "Fisherman's Friend". In more prosperous days though, the Mullard company, a wholly owned subsidiary of Philips since 1928, operated an electronics factory there before it closed in 1979.

The Fleetwood logo used on many Mullard radios, including the set described here, included a sailing ship. That's because deep sea fishing and cargo shipping were once the main activities of the town. The oak tree dominating the bottom half of the logo was included because oak was used to build sailing ships.

Philips in Australia

The Adelaide suburb of Hendon originally hosted an airfield but this had become vacant by the start of World War 2. Soon after the outbreak of war, a large munitions factory was built there and produced around three million .303 bullets a week (the author's mother was employed there during that time). Philips subsequently took over the buildings in 1947 and continued radio and electronics production there until 1980. At its peak in the late 1950s, some 3500 people worked for Philips at Hendon.

During the 1940s and 1950s, Philips radios were also badged as "Mullard" or "Fleetwood". There were some minor cosmetic differences between them though. For example, the circuit diagrams of the Philips Model 164 and the Fleetwood Model 1003 both appear in the 1955 Australian Official Radio Service Manual (AORSM) and are identical (these stablemates would have been made at the Hendon factory). However, apart from its logo, the Fleetwood Model 1003 is easily distinguished from the electrically-identical Philips Model 164 because it uses a cloth speaker grille rather than a metal mesh.

That aside, these two sets really are twins. Both have "4 VALVE" stamped into the fibre of their wrap-around backing panels and they have the same information on the labels (although the Philips' label is red while

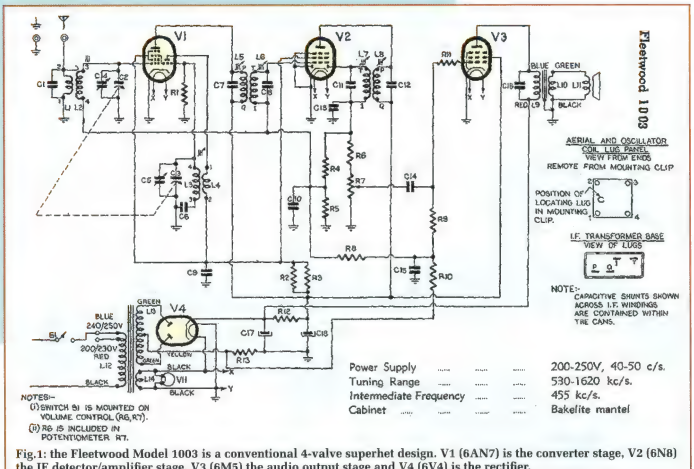


Fig.1: the Fleetwood Model 1003 is a conventional 4-valve superhet design. V1 (6AN7) is the converter stage, V2 (6N8) the IF detector/amplifier stage, V3 (6M5) the audio output stage and V4 (6V4) is the rectifier.

the Fleetwood's is green). Rather strangely, the cabinet could either be a walnut-coloured Bakelite type (as for the Model 164 shown here) or a thermo-moulded plastic type for colours such as the cream Fleetwood. In fact, this would have been one of the last Bakelite cabinets used because they were more expensive to produce and it was more fashionable to use bright colours during the 1950s to match the kitchens of the day.

Circuit details

The Fleetwood 1003 incorporated a number of the advances that were made during the 1950s, including the use of "modern" 9-pin valves to optimise various circuit functions. The result is a 4-valve radio that's a solid performer in reasonable signal strength areas. Alternatively, a buyer in 1955 could have paid slightly more to acquire the Philips 5-valve Model 165 in the same moulded case.

Fig.1 shows the circuit details of the Fleetwood Model 1003. It's a conventional superhet design with V1 (6AN7) operating as the converter, V2 (6N8) as an IF detector/amplifier stage, V3 (6M5) as the audio output stage and V4 (6V4) as the rectifier.

Unlike the Fleetwood set, the Philips 5-valve model 165 uses two valves to achieve IF amplification, detection and AGC – see Fig.2. In this circuit, V2 is a 6BH5, while V3 is a 6BD7 which subsequently drives a Philips Miniwatt 6M5 output pentode. By contrast, in the Fleetwood circuit (Fig.1), a single 6N8 (V2) performs IF amplification, detection and AGC.

Either way, it makes no difference to the performance. The author has a Model 165 to compare with the Fleetwood and finds it impossible to distinguish between them on listening tests.

The 9-pin 6M5 power pentode (V3 in the Fleetwood) has a gain of 22 in typical use and this is adequate to avoid the need for extra preamplification after the IF stage. In fact, R6 is a 400kΩ series resistor that's actually built into the 100kΩ volume pot (R7) to reduce the signal that's fed from the 6N8 to the 6M5 audio output valve. The 6M5 can easily deliver 3W of audio, which is more than enough to drive the 5-inch (125mm) Rola model C speaker used in the Fleetwood into overload.

The 6M5 valve was common in many radios of the 1950s and 1060s, by the way.

Restoration

One of the first things I noticed when

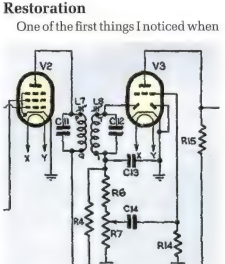


Fig.2: unlike the Fleetwood set, the Philips 165 uses two valves for IF amplification, detection and AGC.

In addition to its distinctive logo, the Fleetwood Model 1003 (left) is easily distinguished from the electrically-identical Philips Model 164 (right) because it uses a cloth speaker grille rather than a metal mesh grille.

VALVE EQUIPMENT AND VOLTAGE ANALYSIS

Valve Function	Valve No.	Valve Type	Plate Volts	Screen Volts	Osc. P. Volts
Frequency Converter	V1	6AN7	210	55	55
I.F. Amplifier, Demodulator and A.V.C.	V2	6N8	210	55	—
Power Amplifier	V3	6M5	208	210	—
Rectifier	V4	6V4	V4 cathode — L13 C.T., 232V.		
Dial Lamp	V11	6.3V, 0.32A tubular screw			
Voltage across R13, –6.7V					

Fig.3 (above): this chart lists the valves used in the Fleetwood 1003 and their screen and plate operating voltages.

The Philips Model 164 and Fleetwood Model 1003 are virtually identical. Even the labels on the back are the same, except that one is red and the other is green.

I acquired my Fleetwood 1003 was that green corrosion spots were apparent in the gold finish of the facia. This suggests that the gold finish was formulated in part with copper.

In addition, the speaker cloth on the Fleetwood had been badly stained down the lefthand side by a green-black goo that had also dribbled onto the gold trim and the tuning dial. This goo appeared to be acidic and had created a copper salt wherever it had affected the finish.

The solution to this cosmetic problem was to remove all the parts from the case (as described later) and thoroughly clean it and the grille with degreaser. The black dial background and the cream sections of the cabinet were then covered with masking tape and paper, after which the exposed facia and grille fabric were sprayed with gold paint.

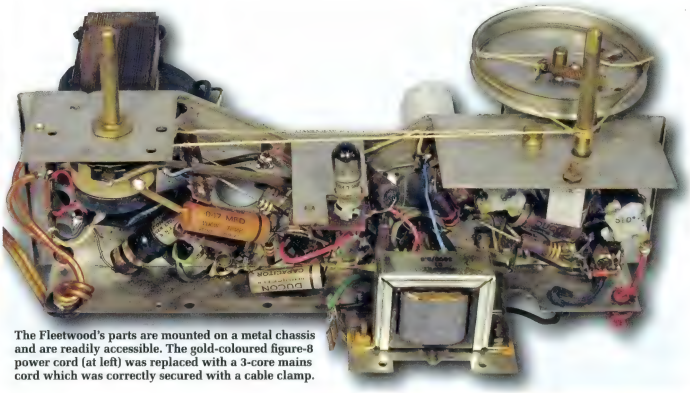
Although it is not an intuitive thing to do, speaker grille fabric takes paint well and in this case, the result was quite good. The cream feature-strip at the front of the case was then restored by sanding off the new gold coating with fine-grit sandpaper.

Beginner's trap

By the way, there's a beginner's trap built into all the Philips clones that use this cabinet. Indeed, I have been guilty of breaking a perfectly good dial cord on one of these sets.

To the uninitiated, it seems that all that needs to be done to remove the chassis is remove the knobs and then slide the chassis out. However, Philips didn't make it that simple. They can be annoying in their engineering designs and they get my vote for the manufacturer who most consistently made disassembly difficult.

In these sets, the dial pointer is awkwardly poked up from under the back plate behind the dial assembly and if you simply tug on the chassis, the dial cord breaks. The correct procedure is to first remove the plastic calibrated



The Fleetwood's parts are mounted on a metal chassis and are readily accessible. The gold-coloured figure-8 power cord (at left) was replaced with a 3-core mains cord which was correctly secured with a cable clamp.

dial panel at the front (two screws) and then guide the dial pointer under the backplate that is part of the cabinet moulding as the chassis is withdrawn.

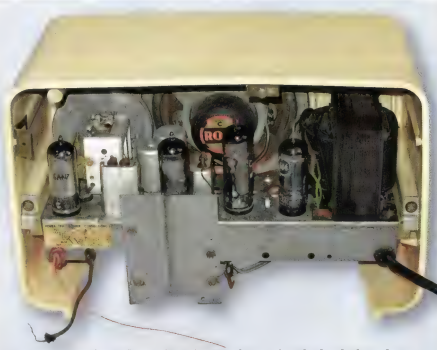
In my radio, the dial had already been restrung but with ordinary string rather than dial cord. This suggests that someone else had previously fallen into that beginner's trap. Despite using ordinary string, the restrung dial worked quite well, so I left it as it was.

Another aspect of this radio is that the Rola 5C speaker is tightly clamped into a circular groove in the back of the case moulding. This makes an effective baffle for the speaker but means that the speaker's wires must be desoldered to remove the chassis.

Chassis work

My Fleetwood 1003 radio was received in working order and all the parts under the chassis appeared to be in good condition. That meant that there was little to do other than tidy up the rather messy layout. Indeed, one essential chore was to replace the rather stylish gold figure-8 2-core flex with a 3-core mains power cord and to properly secure this with cable clamps.

The speaker transformer at the bottom was still lustrously metallic and clearly stamped Plessey-21– 5000/3.5 (the latter numbers designating the input and output impedances in ohms).



The chassis can be slid out of its plastic cabinet after the knobs have been removed but you also have to be sure to remove the dial panel and guide the dial pointer under the dial backplate as you do so. This view shows the chassis after restoration.

As an aside, Plessey took over Rola, based at Richmond in Melbourne, in the mid-1960s.

The top of the chassis carried the classic "miniature" Philips IF transformers of the era. It also featured the characteristic Philips compact tuning condenser with brass plates that was carried over to early Philips transistor radios.

One problem was that a large amount of dust had covered the valves and

This rear view shows the Fleetwood 1003 fitted with its punched fibre-board cover. The two leads at lower left are for the antenna and earth connections.

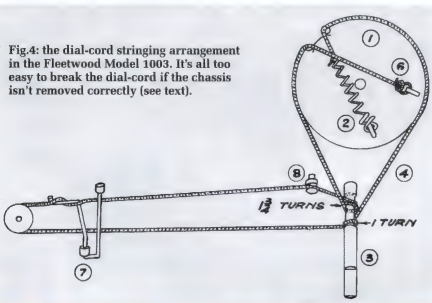


Fig.4: the dial-cord stringing arrangement in the Fleetwood Model 1003. It's all too easy to break the dial-cord if the chassis isn't removed correctly (see text).

other parts on the top of the chassis – this despite the back of the set being protected by a punched fibre-board cover. This dust and any associated grime were removed by brushing the parts with mineral turpentine and then air-blowing the chassis dry.

ARTS&P label

Prior to this clean-up, a small fragment of the ARTS&P label had been evident on the chassis to the left of the power cord grommet. I sometimes replace a missing or damaged ARTS&P label with a reproduction but in this case it wouldn't be seen with the backplate installed, so it was omitted.

Pitted dial plastic

One blemish that couldn't be repaired was the pitted area of the dial plastic where the corrosive goo had etched into it. Even a deep polish using old Brasso failed to go deep enough to remove this pitting. Old Brasso, by the way, is formulated with kaolin and quartz instead of silica for the abrasives and the suspension compounds do no harm to most plastics. On the contrary; those fine abrasives restore most plastic surfaces to spectacular clarity.

Unfortunately, the Brasso formula changed in 2008 to comply with US volatile organic compounds laws and the new formulation cannot be used on some plastics. I am now down to my last few millilitres of the old Brasso, so I will have to find a suitable substitute.

Finally, the Fleetwood's cream cabinet would easily blend with any decor and the radio is relatively small, with a width of just 280mm. The set is perfectly functional and its appearance respectable enough to be placed in any modern kitchen. SC

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RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	10105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
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DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110122	$20 per set
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GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
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PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
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REVISED 10-CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
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TINY TIM AMPLIFIER PCB as Headphone Amp (Sept'11)	OCT 2013	01309111	$20.00
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STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
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PORTABLE-D MAIN BOARDS	DEC 2013	01111131-3	$35.00/set
(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above [Nov 2012/May 2013])			
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VALVE SOUND SIMULATOR PCB	AUG 2014	01106141	$15.00
VALVE SOUND SIMULATOR FRONT PANEL (BLUE)	AUG 2014	01106142	$10.00
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APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$15.00
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NEW-THIS-MONTH

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ASK SILICON CHIP

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Driveway monitor on a farm

My cousin lives on a farm whose front gate is about 8km from the entrance gate and he occasionally gets uninvited pig shooters coming in and going down a side road and thus away from the homestead. Fortunately, he does have 3G mobile coverage at the gate.

Would it be possible to have a variation of the Driveway Monitor, from the June & July 2015 issues, which would replace the 433MHz transmitter with a device which would send one of two pre-recorded SMS messages (depending on the direction of the vehicle detected) to his mobile? This would need a SIM card and only be activated when the unit detected a vehicle.

This would make the Driveway Monitor truly useful on a farm. (D. B., Artarmon, NSW).

● It is possible to send any detection of a vehicle via SMS using the Arduino-based GSM Remote Monitoring Station project that was published in March 2014 (a 2-page preview is at www.siliconchip.com.au/Issue/2014/March). This can be used to monitor the Driveway Monitor's RA4 and RA6 (pins 3 and 15) outputs of IC2. These drive the entry and exit LED but can be used as detection information where one of the outputs goes to 5V when a vehicle is detected (one for each direction).

The Arduino-based GSM Remote Monitoring Station requires about 30mA at 6V and uses a 1.3Ah SLA battery. A 6V solar panel could be used to maintain charge.

Driveway sensor location is not critical

The Driveway Monitor article indicates that it can be placed "somewhere alongside the driveway". So will it work OK when located in the ground next to the driveway? On the nature strip side of the front gate?

My guess is that the magneto-resistive sensor would work OK but the antenna would have to be connected via a coax cable along with a power cable. Is this possible? Or is it sensitive enough that it could be mounted on the fence next to the front gate and then detect a car before the gate is opened? (R. W., via email).

● You can place the Driveway Monitor in the ground so that the vehicle is detected as it goes past. However, before installing it, it would be wise to check its operation above-ground.

The Driveway Monitor is more sensitive when the bulk of the vehicle is near the sensor and becomes less sensitive the further away the vehicle is. That would be when the sensor is below the ground and beside the vehicle's wheels.

The antenna should be OK left inside the Driveway Monitor box if you only require less than 20m UHF range to the receiver.

Driveway Monitor speed limit?

Just checking if the sensor in this project will detect cars travelling between 50-80km/h? Will it work at those speeds? (J. H., via email).

● The HMC1001 sensor itself can be really depends on the state of charge and condition of the vehicle battery. A vehicle battery with a high impedance cell for example will show an increase in voltage up to almost the open-circuit jump starter voltage before any current is drawn. Alternatively, a good battery that is just discharged may rise somewhat less.

Interestingly, in some cars, if the battery voltage is marginal but still allows the starter motor to crank the engine, it may still not start because the ECU prevents it. In those cases, the only long-term solution is to replace the battery. We believe that this problem does not affect many recent car models.

Just by coincidence, we have an article on lithium battery jump starters elsewhere in this issue.

Jump Starter Does Not Fool ECU

I recently picked up a jump starter unit from a rubbish heap so I could view the internals. It consisted of an extra-large motorcycle battery with heavy-duty cables to the clamps and miscellaneous light-duty wiring to the meter, light, cigarette socket etc. Charging appeared to be via a 12V 0.5A trickle charger.

My conclusion is that the fully-charged "jump-start battery" gives a "false 12V" to a vehicle, thereby over-riding the car's ECU which I believe is programmed to isolate/cut-out the starting circuit if the car's battery is below 10.5V. Is this correct? (C. R., via email).

● Such a jump starter essentially connects in parallel with the existing vehicle battery to provide sufficient charge (energy) to enable the starter motor to run in order to start the engine. The jump starter's battery prevents the vehicle's battery voltage from dropping markedly while starting simply by being in parallel with the vehicle battery and supplying the bulk of the starting current.

The jump starter also does charge the main battery but this charging is limited due to the much lower ampere-hour capacity compared to the vehicle battery. Once the engine is started, the vehicle's alternator can continue charging and the jump starter can be disconnected.

Hence, a jump starter does not provide a "false 12V" supply but a genuine supply that has sufficient power for the vehicle to be started. What voltage the supply will be when the jump starter is connected

used for detecting vehicles travelling at well beyond 100km/h. The sensor has a bandwidth of 5MHz so could conceivably detect vehicles passing by at a rather rapid rate. The main limit would be the added circuitry to amplify and process the sensor signal.

However, the Driveway Monitor project itself is not designed for detecting high-speed vehicles, as it is for a more leisurely-paced driveway application (up to 40km/h).

Special Function Timer operation puzzle

I built the Special Function Timer (Silicon Chip, October 2008) for use in a tram control system. I am a volunteer with a local tram preservation group and would appreciate if you could possibly shed some light on why the above timer failed to operate after being installed.

The tram runs on 600V DC and it uses a 12V battery system to run indicating marker lights and solenoid-operated pneumatic actuators for the doors. The actuators require a short duration 12V pulse to open and close. There is a 600V-13.8V DC-DC converter battery charger installed which was operating during the tests.

Two fuses protect the supply and these did not blow during the testing. The main 12V supply switch operates a relay with the contacts switching the supply to lights etc on and off. When functioning correctly, turning the main 12V switch off automatically opens all the access doors which is a safety feature of the tram operation.

The timer is set for a one second delay, single-shot with H/L triggering. There is a connection from the 12V supply to both NO relay contacts with the commons going to the actuators, two circuits each for a total of four doors. The negative is not bonded to the tram chassis. All 12V negatives are wired directly back to the battery, to maintain isolation from the 600V grounding system of the tram carriage.

I built the timer and successfully tested it on the bench using a 12V battery. When installed in the tram, it failed to work and I noticed the board became quite warm around the area of the voltage regulator. In quite a few attempts, the LED and relay operated only once to open the doors. Unfortunately, I am not sure what switch or buttons the driver was pressing at the time and I couldn't replicate the operation.

I removed the board and brought it home to do some more testing. With no changes to the settings and no load connected to the relay, both the LED and relay operated but only while the trigger voltage was applied. I tried lengthening the time period and the relay and LED stopped operating. I put the time back to one second and now the relay and LED do not operate at all and the regulator heatsink becomes too hot to touch.

The regulator is still putting out 5V but it appears that the timer is dead. With just the 12V supply connected the timer is drawing nearly 0.5A which seems rather excessive. I am pretty sure that all components are in the correct place and polarities correct.

Is the 13.8V supply voltage via the battery charger too high and thereby caused the problem? In my haste to install it, I may have swapped the 12V supply with the input signal but looking at the circuit I am reasonably confident this would not have caused the problem.

It may well be a coincidental compo-

12V Stereo Amplifier Power Output

I built the 12V Stereo Amplifier from the May 2010 issue and have a problem with it. The amplifier produces clean sound but it does not seem to be producing anything like the power described in the article.

Unfortunately, I have not yet built my AC millivoltmeter project so I can't give you a power measurement. However, when driving the amplifier from a CD player, it draws less than 300mA from my bench supply. Feeding the input via an audio preamplifier increases this current draw to 500mA.

I fed the amplifier with a 1kHz square-wave and with an amplitude of 1V the amplifier is drawing 600mA. If I increase the amplitude of the square-wave to 3V, the amplifier draws 1.4A, with both channels fed. Increasing the supply voltage from 12V to 15V appears to make almost no difference.

The tone controls and the volume control operate as expected and there is no audible distortion in the sound produced. Pins 3 & 13 on the TDA-7377 have a Vcc of 12V. Given how few components are involved I am unable to determine how to resolve this. Also, given the location of the power switch, am I correct in thinking that the TDA7377 is on as long as DC is connected? (B. D., Hope Valley, SA).

- You haven't said what the load impedance is. As stated in the introduction to the article ". . . it will deliver 20W per channel into 4-ohm loads at clipping . . .". This was verified on our prototype.

You really need to measure the RMS voltage output and current to get a true idea of the power being delivered. With resistive loads you can infer the current but with reactive loads this is difficult.

The TDA7377 has a fixed gain of 10x per side. So you should not need to have more than 1.2V peak-to-peak or around 850mV RMS at the inputs of this IC for full power with a 12V supply. Part of the problem may be that if you feed in a square-wave, its shape will be affected by the tone control section. We normally test power with sinewaves as they are more representative of actual signals.

If you want to test its power output properly you need to feed a ~1.2V sinewave into each input, with the signal generator set to, say, 50-100Hz which will be suitable for most DMMs. At maximum volume, you should get a signal swing (measurable with a good DMM in AC volts mode) of around 12V peak-to-peak or 4.25V RMS at each output terminal, with respect to ground. If you then connect an 8-ohm load across one pair of output terminals, this will have around 8.5V RMS across it, for an output of just under 10W.

The input current to the amplifier should be just over 1A RMS. Loading up both channels should result in double this power draw. Using 4-ohm loads will allow you to achieve maximum power, which will not be at full volume as the outputs will overload.

You can't get a sensible power reading when playing music since the average power level is well below that of a full-scale sinewave.

Loudspeaker Protector Has AC Sensing Fault

I've built the Loudspeaker Protector from the October 2011 issue using the Altronics kit (Cat K5167). I have a question about the "AC Sense" input rating of 50VAC.

My amplifier uses a 25-0-25V toroidal transformer. It actually measures 56VAC at the AC terminals of the rectifier. I've tried using one winding and the centre tap but the relay doesn't turn on. I suspect this is because the centre tap is common with the 0V rail of my power supply board. I am using the 37V DC output of this power supply to supply the Loudspeaker Protector.

Will the circuit be OK in the long-term with 57VAC at the AC Sense input or should I modify it in some way? (C. C., via email).

● The 50VAC maximum rating for those inputs is with respect to circuit ground, so it should be OK to connect both ends to CON2 and ignore the centre tap. However, it should have still worked even the way you connected it so we suspect you may have a circuit fault. The centre tap connection would have done nothing as its associated diode would never have been forward-biased but the other connection should have been enough to get the relay to turn on.

First, we would check for AC voltage at the cathode of diodes D2 & D3 with your amplifier powered up. With one transformer winding connected (as you explained) you should get a reading of about 14VAC, or 28VAC with both connected. Next, check for voltage at the base of Q1, which can be probed at the end of the 12kΩ resistor just below it. It will probably read less than +1V but you should get a non-zero reading.

Next, measure the voltage across the 470nF capacitor which can be probed at the lefthand end of the 100Ω resistor to the left of Q1. It should be low – less than 0.5V, indicating it is discharged, as it should be when AC is present at CON2.

With the 470nF capacitor discharged, Q2 is off and the 47μF capacitor at the base of Q3 should be charging up to nearly the full DC supply rail voltage. Check that. With that capacitor charged, there should be little voltage between the collector and emitter of Q3 and therefore there should be substantial voltage across 2.7kΩ resistor R1 – probably about 15V.

In this case, Q4 should be switched on and this in turn should power the relay. If you don't measure much voltage across R1 then there is something wrong with Q2, Q3, D4, ZD1 or one of the associated resistors. If you do find the requisite voltage across R1, then that suggests there is something wrong with Q4, R2 or the relay.

nent failure but I am not sure. I need to build another timer and would prefer it not fail again. Once it is operating correctly, the timer will be used on other trams in the fleet. (D. R., via email).

● The Special Function Timer is protected from damage due to reverse supply voltage connection by diode D1. In addition, the regulator is suited for automotive 12V supplies where the voltage can include transients and can go as high as 14.4V when the battery is under charge. A 12V (or 13.8V) supply to the input will not cause damage as the input is also protected via a 10kΩ resistor with a 16V zener diode to clamp any signal transients.

If you remove IC1 from its socket, then the current drain should drop from the high 500mA to around 10mA. If not, it would suggest that IC1 is at fault.

Alternatively, there could be some other problem such as a short on the PCB somewhere on the 5V supply.

How to produce control panels

I noticed that your labels and artwork for your projects always look very professional. I am after the same look for my projects and I am thinking of building the Signal Tracer/Injector (and RF Probe) from the June 2015 issue. Is there a kit available (or likely to be available in the near future) for this project?

For projects such as this, I wouldn't go to the trouble of etching my own PCBs so if I build it I will purchase your PCBs. Whilst on the subject, rather than me (and others) having to create our own labels, have you thought of being able to sell the artwork along with the PCBs? I think it's worth consideration as the magazine could make a few dollars from the sale and it would save project builders from having to (initially) buy a pack of labels.

Also, do you mind me asking what program you use to create your artwork? It looks very creative and crisp in appearance. (B. H., via email).

● The panel artwork is available free when you purchase the PCB. We generally use CorelDraw to prepare our panels. Altronics are going to produce a kit for this project.

Loss of settings in Garbage Reminder

I built the Garbage & Recycling Reminder project from the January 2013 edition. It worked well for about 18 months but then stopped working. Tests revealed that the battery was flat so I replaced it, fully expecting it to work for next week's rubbish. Sadly this was not to be. It seems it loses its programming when the battery is replaced and I had to do it all over again.

Should this be the case or am I missing something here? Each LED will light up as I press their buttons and it did reprogram. I did put the battery in correctly! (P. C., via email).

● Yes, replacing the 3V cell will cause the settings to be lost as they are not stored in non-volatile memory.

Music for brushing your teeth

Currently, I'm making a little teeth brushing timer for the kids and would like to play some melody to keep it interesting. Generating square-wave tones on a processor pin is an option but not very exciting. The quality is rather poor.

Do you know of any simple audio chip that could get commands from a processor to play selected notes for given durations? The audio synthesiser chips I found are an overkill for this. Adding a simple MP3 player would be possible but there is some lack of control via the processor. (A. H., via email).

● The Digital Sound Effects Module

will play a file lasting up to 60 seconds. You can see a 2-page preview at www.siliconchip.com.au/Issue/2012/September/Digital+Sound+Effects+Generator

Failing that, a smart phone could probably do the same job although that is possibly not a good idea when kids are supposed to be brushing teeth – we speak from long experience!

Oval loudspeaker for a 1970 Holden

I have a 9 x 6-inch 15-ohm speaker retrieved from a 1970 Holden. I believe this type of speaker was also used in Fords of that era. The radios in these vehicles were "Air Chief", designed and manufactured by Radio Corporation Pty Ltd of South Melbourne, Victoria.

The problem is that the speaker cone has deteriorated to the point of being almost nonexistent. Searching through issues of SILICON CHIP has not revealed an advertiser that could recone this particular type of speaker. Unfortunately, during several moves I have likely discarded a few as junk.

I hope you can point me in the right direction as to restoring the speaker I have or can suggest a workaround using a lower-impedance unit. Perhaps a reader has one in their junk/treasure collection. There seem to be speakers with 9 x 6-inch dimensions available, although none are 15Ω.

● You can get loudspeakers re-coned, eg, at http://speakerworks.com.au/ However, you might find that approach is quite expensive and probably more appropriate for hifi loudspeakers. Alternatively, Jaycar can supply a 6 x 9-inch car speaker, albeit they are 4-ohm but they should be OK. Furthermore, if you contact the Historical Radio Society at www.hrsa.asn.au they might be able to help you.

Guitar preamp oscillates at switch-off

I built the 2-Channel Preamplifier from the January 2001 issue of SILICON CHIP. When it is turned off, after about a second or so, it produces significant oscillations.

I have tracked it down to the TL074 quad IC and it appears to be related to the 15V power supply decay, as adding additional filtering capacitors and loading each supply with a 680Ω resistance almost gets rid of it. Is there a solution for this particular problem? (T. M., via email).

● You could try using a larger value capacitor at pins 6 & 7 of IC4b and at pins 1 & 2 of IC4d. So instead of 150pF, use 220-270pF. Also, you could try using an LF347 instead of the TL074. These tend to be better as far as low-voltage operation is concerned.

If you can do so, measure the voltage decay rate at power down for the positive and negative rails. Then load down the slower decaying supply with a resistance so that the voltage drop toward 0V is the same for each supply, then the oscillations are less likely to occur. Adding a 10µF 50V or 63V electrolytic directly across the supply pins (pins 4 & 11) may help.

GPS clock accuracy conundrum

I have built five of the "dead-accurate" 6-Digit Clocks with the GPS module, as described in the May 2009 issue of SILICON CHIP. Four of the clocks are very accurate but one is 44 seconds slow. I changed the PIC chip, the 4MHz crystal and the GPS module but it is still the same.

I can't understand this, as the time is converted from the GPS. I have also recently built two Nixie clocks and they are also dead-accurate from GPS. Is there some other component that I should be looking at? (N. S., via email).

● This problem is not at all easy to understand, because the May 2009 clock simply converts the time value embedded in the NMEA 0183 data stream from the GPS. This makes it hard to see where the problem is coming in.

It must be that with this particular "slow" clock, there is some problem which is preventing the PIC (IC1) from parsing the NMEA data stream reliably. We see that you have tried replacing the PIC, the 4MHz crystal and the GPS module, so that rules out the likely suspects.

To find the less-likely suspects, try replacing the two 22pF capacitors in the crystal oscillator circuit, in case one is faulty and is making the oscillator falter every so often. Also, try replacing diodes D2 & D3 and transistor Q21, just in case one of the diodes is leaky or the transistor has abnormally

Power Transformer Rating For Audio Amplifier

Back in the 1980s, I built a 5-channel stereo version of Jaycar's 8002 mixer. I also built one of David Tilbrook's 170W power amplifiers which we used for one of the stereo channels powering the front of house speakers. I already had an ETI480 100W power amplifier which we used temporarily on the other channel for fold-back.

At the time, I bought a kit for another Tilbrook power amplifier which was going to be used to replace the ETI480 but I never got around to putting it together. My question is: the one 170W power amplifier is running off a 300VA toroidal transformer which was recommended at the time. If I now put the other 170W amplifier together, what are my options for powering the two amplifier modules?

Obviously, one option is to buy another 300VA transformer and duplicate what I already have for the new power amplifier. Or could I replace the 300VA transformer with a 600VA transformer which would run both? Or could I run both modules off the existing 300VA transformer and what would be the result? Would that simply reduce the maximum output and would it be OK providing I didn't turn it up too far? Would I run the risk of overheating the transformer due to it drawing excessive current?

I know that if I was to drop the voltage (by using a lower voltage transformer) then I'm going to run into clipping problems once the AC output voltage swing gets greater than the supply voltage but I don't understand the consequences of lower amps. (B. L., via email).

● Unless you consistently drive your amplifiers to full power (and that is almost impossible with normal music, even driving it into clipping), your 300VA transformer should be more than adequate to power both amplifier modules. We don't know what rectifier and filter capacitors you are using but it is likely that they are also more than adequate.

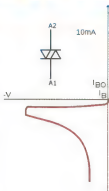
How To Test A Diac

I have in for perusal a partially-assembled electric fence unit that was apparently started in 1995! The circuit uses an automotive ignition coil as the high-voltage source.

Before I start, were there any modifications to this project? If available, a schematic would assist. Also, I have been using another one of your designs which I constructed, a Zener Diode Tester to check Diacs. It gives a gives a go/no go indication, eg, 24-27V. Presumably, this is applicable? (I. P., via email).

● The Electric Fence Controller was published in July 1995 and Notes & Errata were published in December 1995 and December 1998. You can order photocopies from our on-line shop at www.siliconchip.com.au/Shop/2 If you order a back copy of the article, specify that you want the Errata included.

Using the Zener Diode Tester (SILICON CHIP, November 2011) to check Diacs can show unexpected results. That is because when a Diac breaks



over at about 30V, it has a negative resistance characteristic and shows a low voltage as depicted in the accompanying graph.

By comparison , a zener diode typically breaks down close to its zener voltage and has a relatively small change in voltage versus current compared to the Diac. Having said that, your results probably indicate that the Diac is OK. By the way, if you are using the Zener Diode Tester to test a Diac, it should be tested for both polarity directions.

low gain. These could cause the NMEA data stream to be corrupted in a way which prevents the PIC from parsing it reliably and continuously.

If neither of the above fixes the problem, look carefully at things on the GPS module board. Is the correct supply voltage being fed to the GPS module you are using? If so, try replacing the BC338 buffer transistor in case it has very low gain and may be delivering a weak output data stream.

Winding air-cored chokes is a challenge

I plan to assemble the following SILICON CHIP projects using the complete kits available on Altronics website: the Ultra-LD Mk3 135W stereo amplifier (with two amplifier modules, power supply, speaker protection, input selector and preamp boards), the 20W Class-A stereo amplifier and the Studio Series Preamplifier. These units won't be used together as each will have a specific use, in my video post-production and audio restoration units.

I contacted Altronics in order to obtain some information about these kits and in particular to ask if the air-cored inductors in each kit are already wound or if they need to be. Unfortunately, Altronics has confirmed that the air-cored inductors do need to be wound. Even if the assembly of these projects does not seem to be difficult for me, I'm facing difficulties in making the inductors. I did some tests and I was unable to build good ones.

I tried to find pre-built air-cored inductors which can suit, (eg, 4.7µH, 6.8µH and 10µH) but I did not find any corresponding inductors, in the element14, Radiospares or Digi-Key online catalogs. So I'm looking for someone who can build these inductors for me. Of course, I'll pay for the air-cored inductors to be made, as well as the shipping cost to France. Do you have any suggestions? (L. O., via email).

● Winding the inductors is really quite easy and we included instructions and photos on how to do so in the articles on the Ultra-LD amplifier. Even if you cannot obtain the plastic formers, it is relatively easy to wind the necessary turns of enamelled copper wire onto a former made from a 10mm length of 11mm diameter rod, with two end cheeks of plastic, wood or metal bolted together. After the choke is wound, the former would be disassembled to remove the choke.

To make sure that the choke does not tend to deform, you could dip it in hot wax; when it cools the wax will hold the turns rigidly.

2kW sinewave inverter is now obsolete

I need a full circuit of your 2kW pure sinewave power inverter circuit. I searched your website and found five parts, from October 1992 to February 1993. I need a full circuit so how can I get it? (S. M., via email).

● This project is now very old and it is doubtful whether it is a worthwhile approach. However, if you want the circuits you need the articles published in the November & December 1992 issues.

You can order these on our website at http://siliconchip.com.au/Shop/2

Corner frequency for the Bass Extender

I built the Tiny Tim amplifier and speakers (October 2013 to January 2014) and plan to put the Bass Extender (SILICON CHIP, January 2014) in the amplifier. My question is, do I use the roll-off frequency of 100Hz for the Tiny Tim horn-loaded speakers to set the resistances in the bass extender? (G. M., via email).

● It's difficult to judge exactly what you should set as the corner frequency for the Bass Extender when used with the Tiny Tim speakers. This is because we've published two different frequency response plots, one in line with the driver and one in line with the horn, but nothing giving an overall response which would be more representative of what you would actually hear. So you need to effectively average the two plots.

Looking at the response plot diagrams, 100Hz is probably close to the right value. Arguably you could possibly go higher, maybe to around 120-150Hz. Try 100Hz and see how it sounds – it isn't too difficult to change the resistors and you do have some adjustment range with the on-board trimpots.

Even when you have a good frequency response plot and specifications for a speaker, sometimes you have to tweak the corner frequency to get the flattest sounding response. This can be due to

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Wideband oxygen sensor interface

I want to read an LSU4.2 AFR (air fuel ratio) sensor from my controller. Can you help me? Which product must I buy? (V. L., via email).

● We published articles on building a Wideband Oxygen Sensor interface for the Bosch LSU4.2 sensor in our June, July and August 2012 issues. This unit provides linear and S-curve analog outputs. The linear output is 0-5V for 0.7-1.84 lambda values. A display unit which provides a numeric and bargraph display is also described in these articles.

These issues are available as either printed magazines on our website or for online viewing. We can also supply PCBs and programmed microcontrollers to build the sensor and display units. However, you would have to source the other parts yourself and do the assembly work, including soldering.

Almost all the parts (besides the ones we sell) are standard and should be available from any large electronics retailer. The only real exception would be the optional pressure sensor, which provides more accurate readings when the sensor is exposed to significant exhaust pressure. The other parts which may require a specialist supplier are the cables and connectors for the oxygen sensor, although it is possible to make your own. SC

Notes & Errata

Driveway Monitor (July 2015): IC1 is incorrectly listed as an AD723AN in the parts list. It should be an AD623AN as shown on the circuit. This error has been corrected in the on-line edition of the magazine.

Next Issue

The September 2015 issue of SILICON CHIP is due on sale in newsagents by Thursday 27th August. Expect postal delivery of subscription copies in Australia between August 24th and September 4th.

Ultra-LD Mk.4 Amplifier Module, Pt.1 – continued from p39

the exception of C0G/NP0 types, have very high voltage coefficients. As the voltage across the capacitor increases, its capacitance drops. While electrolytics have a reputation for non-linearity, they are nowhere near as bad as these multi-layer ceramics in this respect. It's so bad that with just 10mV RMS across the coupling capacitor, we were measuring distortion levels as high as 0.1% at 10kHz.

Luckily, the same attribute that gives C0G/NP0 a near-zero temperature coefficient means they also have a very low voltage coefficient and so are free of this problem.

The output filter capacitor can either be a high-voltage SMD NP0 ceramic or through-hole polypropylene. Its linearity is absolutely critical to performance. Both types are acceptable. However, the NP0 ceramic may be a better bet as we've found several different 250VAC polypropylene capacitors with less-than-ideal linearity.

We tested several suitably-rated polypropylene capacitors, some of which were X2 types, intended for mains applications. Of these, two introduced measurable distortion of around 0.001% in a simple RC filter (with a 6.8Ω resistor) at just 12V RMS. One X2 capacitor, and the a 400V DC/250VAC type from Epcos/TDK, measured much lower at around 0.0004%.

So if you are going to use a polypropylene capacitor we highly recommend sticking to the type we have specified in the parts list. Others may have similarly low distortion but without a high-performance distortion analyser, there's no way of telling. We do not recommend you use an X2-rated polypropylene as a consequence.

Semiconductors

In the preview last month, we explained the rational behind changing the small-signal transistors and the advantages of the new parts. Besides replacing the obsolete parts, one of the biggest benefits is that with the input pair in a single package, there will be very little drift in the output offset voltage with temperature as they will track closely.

The output transistors, driver transistors and V_{BE} multiplier are identical to those used in the Mk.3 amplifier as these all need to be mounted on the heatsink. The driver and output transistors are among the best available so we didn't see any point in changing those. By the way, the heatsink mounting arrangement is identical, so it's easy to replace a Mk.2 or Mk.3 module with the Mk.4 version, by simply replacing the PCB assembly.

Next month

That's all we have space for now. Next month we will present the power supply, PCB overlay and photos of the final prototype, along with construction details. We'll also describe a slightly cheaper, cut-down version of the amplifier for lower power applications, without compromising its excellent performance. SC

Advertising Index

Altronics 80-83
Aust. Exhibitions & Events 5
Av-Comm Pty Ltd 7
Emona Instruments 63
Gooligum Electronics 12
Hare & Forbes ..... OBC
High Profile Communications 111
HK Wentworth Pty Ltd 64
Icom Australia 13
Jaycar IFC,53-60
KCS Trade Pty Ltd 75
Keith Rippon 111
Keysight Technologies 65
LD Electronics 111
LEDsales 111
Master Instruments 3
Microchip Technology 11
Mikroelektronika ..... IBC
Ocean Controls 8
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Silicon Chip Subscriptions 103
Silvertone Electronics 15
Trend Lighting 111
Tronixlabs 111
Worldwide Elect. Components .. 111

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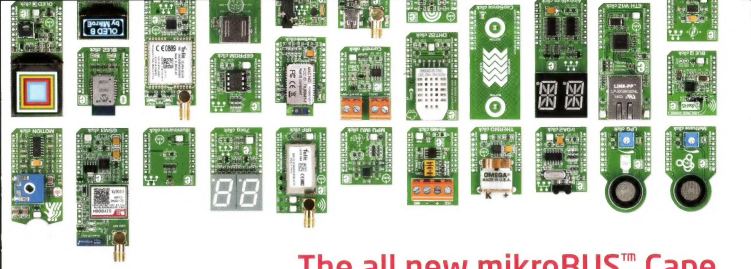

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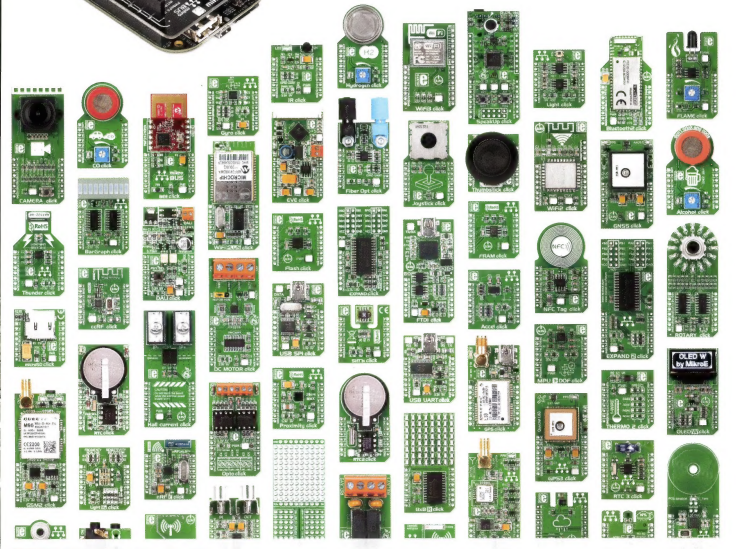

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